International student projects in a blended setting

How to facilitate problem based project work

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PAEE+ALE'2018 | PROCEEDINGS

PAEE

10TH INTERNATIONAL SYMPOSIUM

PROJECT APPROACHES IN ENGINEERING EDUCATION

ALE

15TH WORKSHOP

ACTIVE LEARNING IN ENGINEERING EDUCATION

EXPERIMENT, EXPLORE, DISCOVER & DEBATE

PAEE

PROJECT APPROACHES IN ENGINEERING EDUCATION

ALE

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PROJECT APPROACHES IN ENGINEERING EDUCATION

http://paee.dps.uminho.pt/

http://www.ale-net.org/

This is a digital edition.

WELCOME TO PAEE/ALE’2018

Dear Participants,

Welcome to PAEE/ALE’2018, the 10th International Symposium on Project Approaches in Engineering Education (PAEE) and 15th Active Learning in Engineering Education Workshop (ALE). Educating engineers that will shape our future is an important task. But to be honest, in many places engineering education has a bad reputation: it is boring. Studying to become an engineer is difficult and requires a lot of hard work. Teaching future engineers is a challenging task. But it doesn’t have to be a boring process. Engineering education can be stimulating and motivating by challenging students to solve problems from engineering practice like real professionals.

The PAEE symposium is organised by the PAEE association (http://paee.dps.uminho.pt/) and the Department of Production and Systems of the University of Minho, Portugal, since 2009, and aims to join teachers, researchers and professionals concerned with Engineering Education. ALE (http://www.ale-net.org/) is an international network of engineering educators, initiated in 2000, dedicated to improving engineering education through Active Learning.

In past years PAEE and ALE have been organized in different parts of the world, aiming to enhance Active Learning, Problem and Project-Based Learning in Engineering Education. Participants carried out a variety of activities, including workshops, hands-on and debate sessions, industry panels, interactive poster, paper and keynote sessions, and student project awards. This year PAEE and ALE continue to join forces to create opportunities for learning and networking of Engineering Education professionals who are dedicated to Active Learning. The present events are being hosted by the University of Brasília.

The theme of this year's conference - *Advances in Engineering Education by Inclusion and Diversity* – calls attention to the fact that we should create and foster inclusive and fair environments in engineering, academia, and industry, where every individual is respected, and no one feels marginalized. Gender, race and disability issues should receive more attention in the attraction and retention of engineering students. A report from the National Science Foundation states that broadening participation can infuse science and engineering excellence into varied individual, institutional, and geographic networks and provide for the discovery and nurturing of talent wherever it may be found. May this event give us the opportunity to discuss research and current practice under this challenging theme.

We would like to express our sincere gratitude to the participants that makes this event possible and for all the support that we had during this last year from different persons and organizations.

We hope you will enjoy the conference, the social program and your stay in Brasília.

Rui M. Lima

André Luiz Aquere

João Mello da Silva

Valquíria Villas-Boas

(Chairs of the PAEE/ALE’2018)

"*It is time for parents to teach young people that in diversity there is beauty and strength*"

Maya Angelou

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PAEE/ALE’2018 Invited Speakers

PAEE/ALE’2018 attracted renowned keynote speakers, who are experts at Engineering Education in general and Project Approaches in particular. We are honoured to have the following inspiring keynote speakers:

- Lynn Andrea Stein (Olin College of Engineering, USA)
- Roseli de Deus Lopes (Universidade de São Paulo, Brasil)
- Jennifer DeBoer (Purdue University, USA)

LYNN ANDREA STEIN

Short bio

Lynn Andrea Stein is Professor of Computer and Cognitive Science and Special Advisor to the Provost at Olin College of Engineering. Following a decade as an MIT EECS professor, Stein joined Olin College’s founding faculty in 2000, co-creating innovative curricula and a college-wide laboratory for educational innovation. From 2009, she led Olin’s efforts to collaboratively transform higher education in America and throughout the world, inaugurating the positions of Associate Dean for External Engagement and Initiatives and Director of Olin’s Collaboratory.

Stein's research focuses on the role that interaction plays in both computational and cognitive processes. Her projects have included the construction of an artificial humanoid and an intelligent room, philosophical and pragmatic work from knowledge representation to the semantics of cognition, and co-authorship of foundational documents for the semantic web. Over the past three decades, Stein has also led innovations in computing and engineering curricula including pioneering educational applications of inexpensive robotics, an innovative curriculum for introductory computer science, and an award-winning interdisciplinary, cross-generational design immersion.

As an international advocate for student-centered education and inclusive environments, Stein builds systems and programs for transformation, runs workshops to stimulate curricular creativity, consults with a wide range of US and international institutions, serves on curricular advisory boards, speaks frequently at educational conferences, and embeds in sites to cause trouble and create constructive change.

Stein has received the National Science Foundation Young Investigator Award, a Mary Ingraham Bunting Fellowship, the Helen Plants Award of the American Society for Engineering Education, as well as several teaching awards. She has served on the Executive Council of Association for the Advancement of Artificial Intelligence, in leadership roles in the Association for Computing Machinery, and in various leadership and advocacy positions as a woman in computing. In 2017-2018, Stein is a Fellow of the American Council on Education.

ROSELI DE DEUS LOPES

Short bio

Roseli de Deus Lopes is Associate Professor at Escola Politécnica (School of Engineering), Universidade de São Paulo (USP). She is the vice-chair of CITI-USP (Centro Interdisciplinar em Tecnologias Interativas) and researcher at LSI-USP (Laboratório de Sistemas Integráveis), where she coordinates research projects in interactive electronic media, with emphasis on applications in education, inclusion and health. She is one of the founders of Poli-Edu, a research group on Engineering Education at POLI-USP. She served on the technical/pedagogical working group for the One Computer per Student (UCA), sponsored by the Brazilian Ministry of Education. She coordinates projects aimed at identifying and developing talents in STEM, such as FEBRACE, the largest national pre-college science and engineering fair in Brazil, and InovaLab@POLI, an initiative to provide resources and educational expertise to broaden project-based learning and rapid prototyping for engineering undergraduate students. Recently, she served as a member of Program and Organizing Committees at FabLearn Brazil Conference 2016, Scratch Conference Brazil 2017 and STEM TechCamp Brasil 2018. Currently, she serves as a Director at SBPC, the Brazilian Society for the Progress of Science and Technology.

JENNIFER DEBOER

Short bio

Jennifer DeBoer obtained her Ph.D. in international education policy studies from Vanderbilt University in 2012 and two bachelor's degrees in mechanical engineering and foreign languages from MIT. Before joining the faculty of engineering education at Purdue in 2014, she served as a postdoctoral associate for education research at MIT.

Dr. Jennifer DeBoer is currently Assistant Professor of Engineering Education at Purdue University. Dr. DeBoer strives to better understand and support diverse students around the world as they are empowered to access, develop, and meaningfully apply engineering knowledge, skills, and attitudes. Her work is founded on three important pillars: investigating the ways in which diverse individual students and their experiences are informed by a complex set of contextual background factors; comparing and contrasting the contexts, histories, economies, and social structures of systems of education around the world; and understanding that individual and institutional factors mediate and moderate interactions with technologies and tools to access engineering education. Her integrated research, teaching and mentoring, and service activities therefore look at international and comparative educational settings, technologies and tools that facilitate learning, and the sociological context of education.

Currently, she is investigating the use and effectiveness of online learning programs for displaced youth and adult learners and the participation of women and underrepresented groups in engineering training around the world. She serves as associate editor for the IEEE Transactions on Education. She has been awarded multiple grants and awards from the National Science Foundation (NSF), the American Education Research Association, and the Ford Foundation. During her first year as assistant professor, she received the NSF's prestigious Early CAREER Award.

PAEE/ALE'2018 Debate Panel: Engineering Education Research

During the past decades, the interest in Engineering Education (EE) and Engineering Education Research (EER) has been increasing all around the world. Nevertheless, educators and researchers in engineering schools that dedicate their time to this field of applied research often find themselves in a reverse flow with the most accepted and traditional career paths. Considering that engineering educators are practitioners of EE and sometimes also researchers in EER subfields, this panel aims to discuss the state of the art with respect to EE and EER in higher education and its role in higher education institutions (HEI).

The members of this panel and the audience will discuss the fundamental issues about Engineering Education Research (EER), and the best approaches for developing this field in engineering schools.

- Jennifer DeBoer, Purdue University
- Roseli de Deus Lopes, Universidade de São Paulo (USP)
- Valquíria Villas-Boas, Universidade de Caxias do Sul
- Rui M. Lima, Universidade do Minho

PAEE/ALE'2018 Programme

28 February		01 March		02 March	
8h30 **Registration desk open**		*8h30* **Registration desk open**		*8h30* **Registration desk open**	
9h00 **Opening Cerimony**	**Auditorium**				
9h30 **Keynote session**	**Auditorium**	*9h30* **Keynote session**	**Auditorium**	*9h30* **Engineering Education Research**	**Auditorium**
Lynn Andrea Stein		**Jennifer DeBoer**		Jennifer DeBoer, Purdue Univ.	
Olin College of Engineering, USA		Purdue University, USA		Roseli de Deus Lopes, USP	
				Valquíria Villas-Boas, UCS	
				Rui M. Lima, UMinho	
11h00 Coffee break		*11h00* Coffee break		*11h00* Coffee break	
11h30 Hands-on Sessions HO.A1	Room 6	*11h30* Students Sessions ST1	Room 1	*11h30* Paper Sessions PS.D1	Room 1
Hands-on Sessions HO.A2	Room 5	Students Sessions ST2	Room 2	Paper Sessions PS.D2	Room 2
Hands-on Sessions HO.A3	Room 3			Paper Sessions PS.D3	Room 3
Hands-on Sessions HO.A4	Room 2	Paper Sessions PS.A1	Room 4	Paper Sessions PS.D4	Room 4
Hands-on Sessions HO.A5	Room 1	Paper Sessions PS.A2	Room 5	Paper Sessions PS.D5	Room 5
13h00 Lunch		*13h00* Lunch		*13h00* Lunch	
14h30 Hands-on Sessions HO.B1	Room 5	*14h30* Paper Sessions PS.B1	Room 1	*14h30* Workshops WK1	Room 6
Hands-on Sessions HO.B2	Room 6	Paper Sessions PS.B2	Room 2	Workshops WK2	Room 5
Hands-on Sessions HO.B3	Room 4	Paper Sessions PS.B3	Room 3	Workshops WK3	Room 3
Hands-on Sessions HO.B4	Room LCCC1	Paper Sessions PS.B4	Room 4	Workshops WK4	Room LCCC1
Hands-on Sessions HO.B5	Room 1	Paper Sessions PS.B5	Room 5	Workshops WK5	Room 1
Hands-on Sessions HO.B6	Room 3				
16h00 Coffee break		*16h00* Coffee break		*16h00* Coffee break	
16h30 **Keynote session**	**Auditorium**	*16h30* Interactive Poster Session	Auditorium	*16h30* Debate Sessions DB1	Room 1
Roseli de Deus Lopes		Paper Sessions PS.C1	Room 1	Debate Sessions DB2	Room 2
Universidade de São Paulo, Brasil		Paper Sessions PS.C2	Room 2	Debate Sessions DB3	Room 3
		Paper Sessions PS.C3	Room 3		
18h00 **Welcome**		*18h00*		*18h00* **Closing Cerimony**	**Auditorium**
		20h00 **Symposium Dinner**			

PAEE/ALE'2018 Paper Sessions, Debate Sessions, Students Sessions and Interactive Poster Session

This program of sessions can be changed during the event. Please check the web version for updates.

Sessions	#	Presenter	Authors	Title
DB1				
EN	3	José-Dinis Carvalho	José-Dinis Carvalho, Sandra Fernandes, Rui M. Lima and Diana Mesquita	Making PBL teams more effective with Scrum
	58	Cristiano Vasconcellos Ferreira	Cristiano Vasconcellos Ferreira, Luis Felipe Riva, Paola Bertolo and Viviane Vasconcellos Ferreira Grubisic	Experiences and Challenges in Project Based Learned during Product Design Course – Practical Case
	66	Guillermo Schaffeld	Hanno Hortsch, Diego Gormaz-Lobos, Claudia Galarce-Miranda, Steffen Kersten, Nancy Calisto, Patricia Maldonado, Richard Lagos, Marcela Romero, Jorge Hinojosa, Paul Fuentes, Pablo Rojas, Guillermo Schaffeld, Michelle Paulete, Cristián Millán	Pedagogy in Engineering: A proposal to improve the training of chilean engineers
	82	Luciano Soares	Luciano Soares and Rafael Ferrão	Continuous Integrated Team Learning
	162	José Carlos Reston Filho	José Carlos Reston Filho and Rui M. Lima	Application of the eduscrum methodology to a higher education institution in the Amazon
DB2				
EN	4	Sonja Voorn	Sonja Voorn and Hein Vrande van de	Interdisciplinary medical projects by engineering students: challenges and learning opportunities.
	10	Zehra Cagnan	Onur Deniz Akan, Gizem Bilgin and Zehra Cagnan	Advantages of Industry-Academia Partnerships for the Development of Professional Competences in Civil Engineering
	14	Goretti Silva, Ana T. Ferreira-Oliveira	Goretti Silva, Ana T. Ferreira-Oliveira, Joana Santos, Nuno Domingues and Sandra Fernandes	University-Business Cooperation: Development of a Strategic School Unit at ESTG/IPVC
	157	Jens Myrup Pedersen	Jens Myrup Pedersen, M. Şükrü Kuran, Lukasz Zabludowski, Raphael Elsner and Lauris Prikulis	International student projects in a blended setting: How to facilitate problem based project work
	195	Bart Johnson, Ronald Ulseth	Bart Johnson and Ronald Ulseth	Developing the next generation of cooperative engineering education.
DB3				
PT	63	Sergio Ricardo Mazini	Sergio Ricardo Mazini, Juliene Navas Leoni, Sueli Souza Leite and Priscilla Aparecida Vieira De Moraes	A aplicação do Project Based Learning através de Projetos Integradores como metodologia hands-on para o desenvolvimento de competências
	78	Maíra Rocha	Ari Melo Mariano, André Rodriguez Alves Coelho, Maíra Rocha and Ana Paula Mariano	RESULTADOS DA METODOLOGIA ATIVA NO COMPORTAMENTO EMPREENDEDOR: UM ESTUDO REALIZADO COM GRUPO CONTROLE
	122	Marcito Campos	Simone Borges Simão Monteiro, Ari Melo Mariano, Marcito Ribeiro Madeira Campos, Ana Cristina Fernandes Lima and João Mello	Metodologias ativas aplicadas ao contexto brasileiro: desenvolvimento de um laboratório de observação para disseminação das melhores práticas
	140	Marco Pereira	Marco Pereira and Marina Pazeti	Aprendizagem Baseada em Projetos: Case da Escola de Engenharia de Lorena - USP
	143	Ana Lima	Simone Borges Simão Monteiro, Marcito Ribeiro Madeira Campos, Ana Cristina Fernandes Lima and Ari Melo Mariano	Avaliando resultados diretos e indiretos da metodologia ativa na aprendizagem: proposta de um desenho integrador em 360º via plataforma unificada.
	152	João Carlos Felix Souza	João Carlos Felix Souza, Ari Melo Mariano, Carlos Henrique Marques Rocha, Joao Mello Da Silva and Clóvis Neumann	O Impacto da Aprendizagem Ativa no Conceito de Curso Preliminar (CPC) e na Satisfação dos Estudantes de Engenharia
	159	Maíra Rocha	Maíra Rocha, Ari Melo Mariano, Weryk Henryk Batista Kuhl and Claudia Santivañez Ramallo	Alinhando a Rota: o método BPL como recurso didático na percepção dos alunos de Engenharia de Produção

Poster session				
EN	138	Marcos Henrique de Lima Souza	Marcos Henrique de Lima Souza, Felipe C. Storti, Rita De Cássia Silva and Alessandro Borges de Sousa Oliveira	Kart Team: A Laboratory for Engineering Learning
	4*	Sonja Voorn	Sonja Voorn and Hein Vrande van de	Interdisciplinary medical projects by engineering students: challenges and learning opportunities.
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The PAEE/ALE’2018, a joint organization between the International Symposium on Project Approaches in Engineering Education (PAEE’2018) and the Active Learning in Engineering Education Workshop (ALE’2018), has three type of submissions in up to three languages (English, Portuguese and Spanish):

- **Hands-on and Workshop submissions**, aiming to encourage discussion of current practice and research on project approaches.
- **Full Papers** for paper sessions, including standard research submissions, papers of PBL experiences describing implementation issues. Any of these papers can be selected and presented in a Debate Session, in which a set of papers’ authors will be invited to discuss a common theme.
- **Poster submissions**, including submissions adequate for a poster presentation in an interactive model.

All full paper submissions were double reviewed by the PAEE/ALE’2018 scientific committee, and in same cases add a third review. After notification of acceptance authors were invited to submit a final paper of 6 to 8 pages long in Microsoft Word format, using the available template. Accepted contributions were invited to make a presentation at the symposium.

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PAEE/ALE'2018 LIST OF SUBMISSIONS

PAEE/ALE'2018 HANDS-ON AND WORKSHOPS SUBMISSIONS (ENGLISH)

Submissions accepted for the PAEE/ALE'2018 hands-on and workshop sessions, characterized by being high interactive sessions in which participants and session organizers share their experiences and have common opportunities do develop competences to apply in their own practice.

Do Critical Thinking skills have Gender?

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Abstract

During a long time, women were considered the "weak" gender and even, today, in many countries, unfortunately, this situation continues. Women are not allowed to work, to vote or, even, to make decisions that involve their own life. In the occidental world, women are almost treated in equal terms as men. "Almost" because there are situations were equality seems to exist however, in fact, inequalities are hided in a subtle (and acceptable) form. It is known that the results of any successful interventions promoting gender equality only become visible only after at least five years since the start of their implementation. Bearing this in mind, the earlier the awareness takes place, the more impact it could be achieved. Teachers play a very important part in this process, creating a space for dialogue and discussing in order to overcome barriers to workplace equality, promoting diversity inclusion and identifying common values. A set of questions will be addressed for discussion: Are women and men truly treated equally in learning and employment situations? Do women and men think or look at problems solving in the same way? How are women and men using their critical thinking skills? Do women and men use the same thinking skills? How can these differences be enabled to promote a more harmony environment? The workshop facilitators intend to put participants discussing such questions based on their knowledge and their own experiences. Their answers are important to build healthy professionals and personal relationships among female and male colleagues in learning environments (students, teachers and students-teachers). Workshop participants are expected to increase their knowledge and critical thinking skills related to diversity and equality in the world of work (university, …).

Keywords: Critical Thinking; Diversity; Engineering Education; Skills.

1 Introduction

"*Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness*." - National Council for Excellence in Critical Thinking, 1987.

This definition has 30 years however the first definition has stated in the early 1940's. The Greek etymological origin of the word "critical" is "kriticos" (meaning discerning judgment) and "kriterion" (meaning standards). In that sense, the word "critical" indicates the development of "discerning judgment based on standards."

Nowadays, critical thinking is one of the most required qualities that employers look for in job candidates regardless their field of application and type of service (industry, business, …). Critical thinking is associate to the ability to analyze objectively the information and make a consistent judgment. The five of the most important critical thinking skills that employers are looking for in resumes, cover letters, job applications, and interviews are (1) analytical skills (ability to carefully examine something), (2) communication skills (ability to clearly communicate with others, e.g. sharing conclusions with others employers or with a group of colleagues), (3) creativity (e.g. arise a solution never thought before), (4) open-minded (to be objective, evaluating ideas impartiality), (5) problem solving (this critical thinking skill involves several steps, namely, analyses of a problem, create a solution, and implementation and evaluate of the proposal). More information can be obtaining elsewhere (Doyle, 2017).

It is therefore important to have an understanding of what has been done at the university to inform, to raise the awareness of, to motivate and galvanize students for this purpose.

Pascarella, Palmer, Moye, and Pierson (2001) in their work outlined that the development of critical thinking can be influenced by different experiences and that are based on gender and ethnic identity. Nonetheless the findings, only recently the educators begin to understand the impact of diversity experiences on students' general thinking growth during academy. Later, authors based on a different study, endorses that different experiences raises the development of cognitive growth and more complex modes of thought (Pascarella et al., 2014). Also, the findings stress the educational impact on the students' engagement and that each undergraduate experience may not yield the same benefits to all students (Loes, Pascarella & Umbach, 2012).

Keeping this in mind, on the educators' side, their perceptions and their pedagogic practices in the classroom must, in a continuously way, be challenged.

However, this issue, raises others specific questions, regarding not only to the diversity of experiments but also regarding to the students' characteristics diversity (gender, age, ...), like: Are women and men truly treated equally in learning and employment situations? Do women and men think or look at problems solving in the same way? How are women and men using their critical thinking skills? Do women and men use the same thinking skills? How can these differences be enabled to promote a more harmony environment?

Verawatia, Arifin, Idris, and Hamid (2010) show that besides the slightly difference on the mean scores obtained throughout the Malaysian Critical Thinking questionnaire (MyCT), no significant difference between male and female 16-17 years' students in critical thinking skills, where obtained. However, this reality could be different in a different context.

The number of female students in engineering courses is increasing, so, it is perfectly possible that gender diversity in the classroom can lead to gender diversity in the workplace. However, this increase does not systematically mean an increase on the behavioral changes.

The workshop may be used for trigger for the awareness process for these issues.

2 Activities

The workshop will start with a brief introduction to the topic, a clearer and important concepts information and with some interesting statistics. This part will take no longer than 20 minutes, to introduce the topic and for knowledge levelling, since students and teachers, both from different knowledge areas and different levels of age can take part in this workshop. The participants will be divided in teams, each one with 3 to 4 members, corresponding to a maximum of 10-12 participants. Each team will receive some paper sheets, pens and post-its of different colours.

The participants, together with facilitators, will create practical outputs solving real life challenges provided or even suggested by the participants themselves, always bearing in mind to respond the questions posed. This part will take around 45 minutes. At the end, each group designate one of its members to be its spokesperson that summarize the main findings.

Approximate duration of the workshop 1.5 to 2 hours.

3 Expected results

After the workshop session, it is expected that workshop participants increased their knowledge and critical thinking skills related to diversity and equality in the world of work (university, ...). Moreover, the findings may be used to prepare a scientific work, if all participants agree.

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Lean Education as a platform to close the academic and professional gap

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Abstract

Academic and professional worlds have been separated during long time by an invisible barrier that apart them from working together. Nevertheless, the academia is preparing the future professionals and to achieve this preparation a matching between what professional needs and academic teaches must be in tune. Despite the important role of the academy in forecasting future needs, practitioners are generally in a better position to do so because they are closer to the marketplace and the corresponding needs. So, a joined work must be done between these two worlds. Lean Education (LE) derives from a methodology that emerged in the industry and nowadays was spread to all industries and services, including the education services, not only as a way to improve these services but, more important, as a pedagogical platform to innovate the learners curricula and better prepare them to professional world. Lean education allows competences development such as systems thinking, critical analysis, sustainability and ethical issues, assessment challenges of the overall performance of a system as opposed to the detailed functions of a component, as well as establishing criteria for, and transparency of decision making. This workshop addresses the above deficiencies from a holistic perspective, accounting for issues in communications, teamwork across discipline and geographic boarders, and project/design status visualization. LE is presented as this holistic perspective and as curricular innovation capable of develop the competencies missing in the current engineering curricula that bridge the gap between the academic and professional worlds. Some questions to be raised in the discussion will be related with: 1) awareness of sustainability and systems concepts of LE; 2) identification of strategies and weaknesses in current curricula; 3) competencies and skills needed to an organizational health and 4) understanding that LE is capable to provide content and competency mastery pulled by stakeholders (society, employers, faculty, and students).

Keywords: Lean education; Competencies and Skills, Engineering Education.

1 Introduction

Lean Production, which has its roots in the Toyota Production System (TPS), was designated by MIT researchers using a different name (Krafcik, 1988; J. Womack, Jones, & Roos, 1990). These researchers rapidly understood that TPS was a different system from very-known mass production system because Toyota was "doing more with less". For them "less" means less human effort, less space, less equipment, less stocks, less product development time, i.e., less of everything - based on exactly what the client wants. Producing or consuming more resources than needed in an activity and that the client was not willing to pay is considered waste by (Ohno, 1988) and this kind of activity should be recognized and, therefore, must be reduced or eliminated. This urgent need came from the constraints that Japan was suffering after the World War II. Nowadays, the epoch is different, but this urgent need continues due to the climate changes and challenges humans face in order to achieve sustainable development and assure the future needs of the next generations (Brundtland, 1987).

Nowadays, no one is indifferent to Lean Thinking principles (Womack & Jones, 1996) that are universally applied to different sectors, from operations to education (Alves, Flumerfelt, & Kahlen, 2017; Alves, Kahlen, Flumerfelt, & Manalang, 2014; Flumerfelt, Kahlen, Alves, & Siriban-Manalang, 2015), being currently assumed as a philosophy and a "way of life". Lean Education is a need in all professionals, from the line operator to the top management administrators because lean solutions (Womack & Jones, 2005) must be found in all activities people do. Even in an Fourth Industrial Revolution ongoing where Industry 4.0 topic (Kagermann, Wahister, & Helbig, 2013) is always in the day agenda, Lean principles are more needed than ever in order to train people so they know that clients must be served but in a "lean way", i.e., delivering the product, just using the resources needed to produce it. Advocating Lean consumption is also part of this training.

This is why teaching Lean is so important, teaching and learning Lean should call for both content and competency mastery (Flumerfelt et al., 2015). This combination is necessary for professional engineering career success, as well as for other professionals from other field (e.g. managers, designers, physicians, nurses, etc.) (Alves, Leao, Maia, & Amaro, 2016). Lean Thinking is not an easy subject because learning is expedited through practice. Thus, Lean Thinking cannot be successfully taught by traditional expositive methods. Based on Lean Engineering learning origins, engineering students need "learning by doing" approaches to internalize such principles into an industrial environment (Alves, Moreira, Leão, & Flumerfelt, 2017).

Even now, with Lean Engineering learning integrated into engineering curriculum in many universities (Alves et al., 2017), there is still resistance to accept it as a different management content for engineering curriculum. Normally, the arguments that Lean is "common sense" or "Lean Engineering is classical Industrial Engineering application" are evoked. It is true that, sometimes, Lean Engineering does apply common sense approaches, but most of the time, it is very counterintuitive, implying a new and active discipline to be effective. Fortunately, many researchers and professionals do understand this discrepancy and have described their ideas, impressions and how they introduce Lean Engineering into curriculum design in several papers in scientific journals, international conferences, and thesis, among others. Some of these works are reported in (Alves et al., 2017).

Today, it is of general knowledge and highly recommended by many reports, that in order for engineering students to be successful in their future professions they need to be skilful both in the engineering contents and competency mastery. Lean Engineering Education promotes and facilitates this mastery by a "learning by doing" approach, based on teaching and learning tools. This workshop will call for the active participation of the participants that will search such tools and will map the Lean Thinking principles "pulled" by each tool.

The workshop facilitators intend to put participants discussing such questions based on their knowledge and their own experiences. The answers given by the participants are important to move towards professional competencies. Workshop participants are expected to increase their knowledge about LE.

2 Activities

The session starts with an "Ice-breaker" activity, then interdisciplinary teams' formation will take place. A maximum of 12-16 participants can be accommodated. The participants will be divided in 4 teams, each one with 3 to 4 members. Each team will discuss some topics such as weaknesses of current problem solving strategies (Content vs competencies, Holistic vs compartmentalized, passive vs active learning methodologies, link to industry,…), Lean Engineering concept, principles, tools and system-thinking, ethics and sustainability competencies. Then some scenarios will be provided to participants to discuss professional competencies needed for industry. It is intended to introduce the taxonomy 3H (Flumerfelt, Kahlen, Alves, & Siriban-Manalang, 2015) to the participants. The workshop will end with a workshop assessment.

3 Expected results

After the workshop session, the participants will understand the fundamental principles/concepts inherent to Lean Thinking and Lean Education and effective tools to teach/learn lean in their classes. The point of the scenarios, planning steps and discussion is to point out the critical need for Lean Engineering Education to closely align with the essentials of engineering practice of the future. The future of engineering professional practice in 2030 cannot be fully understood since no one knows the future. But, by creating and examining viable scenarios of the future as the basis for planning for engineering education, a position is created that asks for decision making by engineering educators to improve pedagogy, curriculum, instruction and assessment.

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The “engineering concept” as a tool to engage students in transversal competences

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Abstract

Including transversal skills as part of course contents can be refused by students due to its amount of subjective-based assessment. The proposed activity in this hands-on sessions can be a way to engage students in transversal skills training. Allowing students to decide which skills are the most important ones and the set of them to be included in the assessment criteria of the course can make it easily accepted.

Keywords: Engineering skills; Students engagement, Transversal competences.

1 Introduction

There are many engineering schools allowing their students to get very high levels of technical background. The idea of engineers being impressive in maths or smarts is widely spread. Notwithstanding it is also widely assumed that engineers are not so good in social skills. This general thought can be found in two different posts inside the engineering web site interestingengineering.com. The first one, by Trevor English is called “Why can’t engineers spell?” and the second one “The world needs more engineers that can communicate”. The gap between “real world” and academic skills and how to avoid it is an issue mentioned in several works (Hutchins, A. (2015), Perkins, J. (2015), Andersson, N. & Anderrsson, P. H. (2010)). From an institutional point of view, the main skills of the 21st century engineer (Samavedham, L. & Ragupathi, K. (2008)) are, among others, creativity and innovation, critical thinking and problem solving, communication, collaboration, information literacy, technology usage, career/life usage and personal/social responsibility. Taking into account the industry perspective, as collected by King, J. E (2007), these skills, by order of importance will be practical application, theoretical understanding, creativity and innovation, team work, technical breadth and business skills. In these works is stated, clearly, the necessity to include the remarked skills as a part of the engineering training process. Nevertheless, explicitly including transversal skills as a part of course contents that will be considered in the assessment can be refused by students (and even by professors) due to the implicit amount of subjective-based evaluation. Making students be aware of the necessity of training this type of skills and letting them to select the set of skills to be included in the final evaluation (and mark) of the course, can lead to a natural way to include them in different courses.

Actually, the activity is carried on with third year students in the context of the course Video Engineering, a course included in the degree in Sound and Image in Telecommunication Engineering. This is a compulsory course, so all the students will have to take part of this session.

2 Activities

The activity I pretend to implement with workshop attendants is a replica of the one I propose to my third year engineering students the very first class day. Working specifically with third year students is an incidental fact related with my actual lectures, but I was doing this with first year students in a very similar way. The way in which the proposal is organised was initially inspired (not copied) by an active key-note by Caroline Baillie titled “Gender inclusive engineering education: A consideration of values” that was done in Toulouse (France) within the frame of the 2007 ALE conference (the key-note sessions are not included in the conference proceedings) (Figure 1). The first part of this session was designed to assess the way in which different engineering related skills was taken into account in attendants’ institutions. The same idea has been re-constructed to generate an activity to introduce engineering skills with students. This activity can be implemented, in a very similar way, with students of different courses and from any discipline (not only engineering ones).

Figure 1. Active session of the 2007 ALE conference (Caroline Baillie is standing in the middle).

In order to know students' feelings regarding engineering skills, an effective way is to make these feelings flow. A group-based activity (3/4 people per group) is organized based on self-ideas about the word "engineering" (figure 2). The whole activity is carried on answering two main questions: What is engineering? / Which are the skills needed to become an engineer? Even though these could seem obvious questions, there is a considerable amount of last year students who has not reflected about them. The final goal of the activity is to make them have an active role stating the most important transversal competences to be included (and, consequently, to be assessed) as course goals.

Figure 2. Students performing the proposed activity.

After ten years performing this activity, there have been a huge amount of different skills selected as the main ones, but there are some of them that are the most recursive. Expressed in groups, figure 3 gives a general idea of the most commonly selected skills. Is important to remark that all of the main groups of skills are among the ones mentioned in the introduction as the most important ones for the 21st century engineer both from an academic and industry points of view.

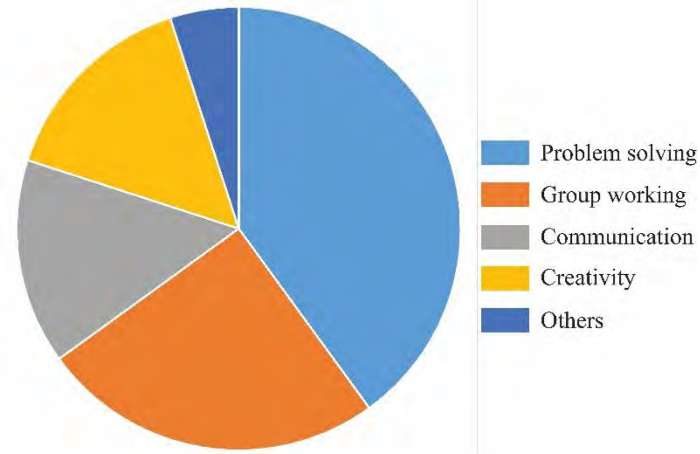

Figure 3. Group of skills selected by students as the most important in engineering.

Besides, secondary outcomes will lead to explore items (among others) like:

- students' conception about engineering,
- the reason(s) why students decided to become engineers,
- students' expectations about working as engineers,
- gender issues,
- social implications of engineering jobs.

Moreover, when working with first year students, this activity is an effective way to introduce them team work and the efficiency of posters as a way to quickly share team results. As can be expected the outcomes of the activity with first year students show a lack of maturity that can be considered to be inherent to the age range of students. As the course in which the activity is actually performed is mainly based on group work, this first session can also be used to establish working groups and to know the limitations of the physical environment (available space, fixed/mobile furniture) for group working. The specific topics treated are different depending on the year in which the students are. In the hands-on activity I will invite attendants to take students' role to let them know the activity and to get their feedback. The participation of students will be strongly appreciated.

3 Expected results

The expected results of the hands-on session can be summarized as follows:

- To discuss with attendants the availability of the proposed activity to engage students in skills training.
- To discuss about academic and industry selection of skills.
- To get feedback in order to improve the activity outcomes.
- To study the possibilities to extend the activity to students of different disciplines.

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Sharing Strategies and Activities that Enhance Creativity in the Educational Environment

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Abstract

It is inquestionable the critical role of creativity for the human potential realization. The capacity for innovation and to solve new problems is a requirement to succeed in this rapidly changing and competitive world. Creative behaviors also contribute to the quality of life, as their expression is usually accompanied by feelings of satisfaction and pleasure, which are fundamental elements of emotional welfare and mental health. Recent trends in creativity have stated that creativity does not happen inside people's heads, but in the interaction between a person's thoughts and a sociocultural context. It is a systemic rather than an individual phenomenon. Creativity cannot be enhanced by isolating individuals from their context. In this regard, there is no doubt that the improvement of students' creativity is a viable educational goal. In higher education, the importance of fostering student creativity has been widely recognized, due to the need for preparing young people for the uncertain and complex world of work, which requires individuals to be able to use their creative abilities. However, results of studies have indicated many barriers to creativity expression as mentioned by undergraduates including Engineering students. Therefore, in this session, several cognitive and affective strategies and activities for helping teachers to foster creative talent in the classroom will be presented. Furthermore, ways to deal with common blocks to creativity will be explored. The creation of an enhancing, harmonious and meaningful educational environment can also contribute to the development of creative potential. In this regard, it will be discussed how to establish a classroom climate that promotes creativity. In this hands-on session, the participants will engage in solving problems activities, as well as planning new ways to infuse creative thinking skills into instruction and innovative strategies to cultivate a culture of creativity in the Engineering education context.

Keywords: Creativity; Classroom Climate; Creative Behavior; Educational Strategies.

1 Introduction

It is unquestionable the critical role of creativity for the human potential realization. Also the capacity for innovation and to solve new problems is a requirement to succeed in this rapidly changing and competitive world (Alencar & Fleith, 2009). The crucial role of the social context for the expression of creativity is also highlighted, as stated by Csikszentmihalyi (1996, p. 23): "creativity does not happen inside people's heads, but in the interaction between a person's thoughts and a sociocultural context. It is a systemic rather than an individual phenomenon" (Csikszentmihalyi, 1996, p. 23). Creativity cannot be enhanced by isolating individuals from their context. In this regard, the influence of the educational context on students' creativity must not be ignored.

The notion that creativity is a gift present in some individuals has been effectively called into question by the expansion of several training programs, techniques and activities around the world, in which the main goal is enhancing creative abilities. In addition, creativity was considered as belonging exclusively to the Arts domain. However, creativity is present in all fields, not only in Arts. Therefore, there is no doubt that the improvement of students' creativity is a viable educational goal. Several scholars have pointed out characteristics of teachers who foster the development of creativity as well as ways to cultivate it in an educational environment (Alencar & Fleith, 2009; Craft, 2005; Cropley, 2004; Fleith, Renzulli & Westberg, 2002; Nickerson, 1999; Sternberg & Williams, 1996; Treffinger, Schoonover, & Selby, 2013).

Therefore, how should teachers foster creativity in the classroom?

(a) Creativity activities and strategies should be incorporated into the regular curriculum. The objective is to get students envolved in solving real-world problems that are studied throughout the curriculum, not merely exposing students to creativity exercises. Creativity activities should not be implemented disconnected from the content or isolated from the school context.

(b) Teachers should be responsive to students' different working styles (alone, in small groups, quietly or discussing his/her idea with a peer etc).

(c) Students should be offered opportunities to work with a wide variety of materials under many different conditions to foster different expression styles. This procedure may increase students' motivation for the task.

(d) Warm-up activities should be developed at the beginning of a creativity session to engage the students in the creativity activities.

(e) Debriefing strategies should be conducted at the end of each creativity lesson (e.g., How many different ideas did you have? What did you think about this?).

(f) Knowledge is important for the creative process. Therefore, teachers should not neglect students' mastery of factual knowledge.

(g) Students should be allowed to share ideas, engage in their favorite activities, express themselves, and become aware of their potential. A non-judgemental classroom climate which encourages creativity and risk-taking may help students to feel safe expressing their ideas.

(h) Teachers should promote correct beliefs about creativity (e.g., that all individuals have the potential for creativity, but it may take many different forms of expression), and get students to take creative behavior as a goal. Students should know that motivation and effort are relevant conditions to be creative. Also, it is important to create a school environment climate where creative behaviors are appreciated and creative habits are instilled.

(i) Teachers should "give students choice wherever possible. If students are presented with just one particular way of doing something, they will become like the rat in the maze who habitually takes the straight, uncomplicated, and uncreative way out" (Amabile, 1989, p. 144).

(j) Teachers should lead students to be aware of his/her strengths and weaknesses as a creative thinker and to find ways to maximize the strenghts and minimize the weaknesses. This strategy implies the development of learning conditions that will enhance students' metacognitive skills, such as self-evaluation, intentional monitoring, and time management.

(k) Teachers should provide balance between structure and innovation in the classroom. On one hand, it is necessary to teach students to recognize and respect rules, bounds, and limits and explain them why the rules are necessary; on the other hand it is important to let students to take risks, to be spontaneous, and original. "The challenge is to find the proper balance" (Nickerson, 1999, p. 418).

(l) It is important that teachers have in mind that they can be models for the students. In this regard, it is essential that teachers should act accordingly to what they advocate. "Attitudes and values that are critical to the development and use of creative potential are best taught by example. I doubt that it is impossible to teach them effectively if one does not have them" (Nickerson, 1999, p. 419).

(m) Teachers should "protect creative students from conformity pressure and establish a classroom climate that permits alternative solutions, tolerate constructive errors, encourage effective surprise" (Cropley, 2004, p. 138). It would be interesting to try to discover the strategy that led to the error.

(n) Neither divergent nor convergent thinking in itself is sufficient for promoting effective thinking and problem solving; both sets of skills must be used in harmony.

(o) Teachers should consider students' interests and learning paces when planning their classes.

(p) Teachers should relate content objectives to student experiences. This strategy stimulates student intrinsic motivation.

2 Activities

In this workshop, the participants will have the opportunity to engage in activities that:

- envolve redefine problems, allowing the student to see a problem in different ways;
- envolve analogical or metaphorical thinking;

- envolve divergent thinking and playing with ideas;
- allow students to generate many, varied, and unusual ideas;
- allow students to create unusual products for an appropriate audience;
- exercise students' imagination and sense of humor;
- encourage students to think of consequences for future situations;
- favor the development of a student' positive self-concept.

This workshop involves approximately eight activities, five of which will be carried out individually, and three in small groups. It is estimated the participation of 15 to 20 people.

3 Expected results

In this session, several cognitive and affective strategies and activities for helping teachers to foster creative talent in the classroom will be presented. Furthermore, ways to deal with common blocks to creativity will be explored. According to Sawyer (2012), "enhancing creativity requires a long-term, multiple-intervention strategy that builds knowledge and expertise, creates exercises to build skills working with that knowledge, encourages searches for novel solutions and strategies for doing that, and evaluates progress and errors" (p. 415). These arguments could be the foundation of any creativity intervention.

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Hands-on Training on Reduction of Setup Times (SMED)

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Abstract

Besides high quality, fast delivery and low price, the current markets demand high product diversity. The mass customization concept confirms this tendency in many types of industries and implies serious challenges to the companies. Thus, the ability to quickly change the type of product being produced (setup process) is a crucial requisite for the companies' competitiveness, and eventually for their survival. Inherent to the Lean Manufacturing paradigm, the Single Minute Exchange of Die (SMED) methodology was specifically developed to reduce the setup time (equipment, workstation, assembly line, etc.), by carrying out a series of stages and using a set of tools/techniques. The objective of this hands-on training session is to teach trainees how to apply SMED in industry. The session includes a brief introduction to the fundamentals of SMED, followed by the hands-on session itself where the trainees will use the so-called SMED kit (physical components), through three runs, to achieve a good solution in terms of setup time. In fact, this session uses a serious game (involves competition), which is a recognised approach to achieve high levels of trainees' engagement and knowledge acquisition/retention. This hands-on session clearly illustrates the application of the SMED methodology, especially in terms of applicable techniques/tools, and can be used both in industry and academia.

Keywords: Equipment Setup; Quick Changeover; Single Minute Exchange of Die; Lean Manufacturing.

1 Introduction

The Single Minute Exchange of Die methodology (SMED) was developed by Shigeo Shingo during 15 years (Shingo, 1985). The objective is to reduce the setup time of equipment/workstation/etc. to a value that can be expressed, in minutes, with a single digit (i.e. from 0 to 9 minutes). However, the ultimate purpose of SMED is to allow the production of very small quantities (ideally just one) of different products. In fact, the Lean Manufacturing approach (Womack, Jones and Roos, 1990; Womack and Jones, 1996), which originates from the Toyota Production System (Ohno, 1988), advocates the adoption of the so-called levelling (heijunka). According to heijunka, even if large quantities of single products are ordered, it is better to produce small quantities of each product every day instead of producing a large quantity of a single product. Thus, the importance of reduced setup times is evident. Typically, a setup process involves several operations, namely:

- Preparation and storage of materials and tools (30%)
- Removal and placement of materials and tools (5%)
- Measurements and adjustments (15%)
- Tests and final adjustments (50%)

According to the SMED methodology, the setup operations are classified as: (i) internal operations – can be executed only when the equipment is stopped, and, (ii) external operations – can be executed while the equipment is running. Table 1 illustrates the SMED application stages along with the corresponding techniques/tools.

Table 1. Stages and techniques/tools of the SMED methodology (adapted from Shingo (1985))

Stage	*Description*	*Applicable Techniques/Tools*
1	Separation of Internal Operations and External Operations	• Checklists • Function checks • Improvement of transports

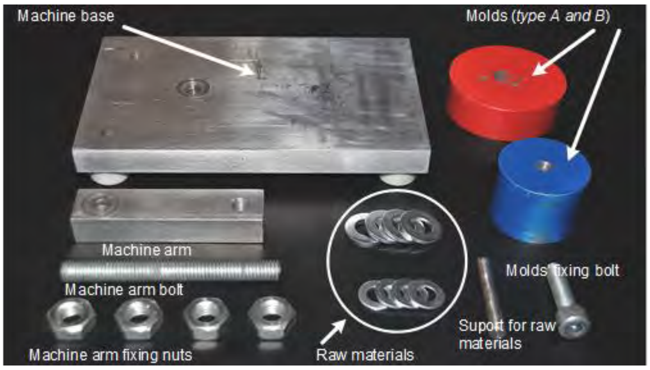
2	Conversion of Internal Operations into External Operations	• Anticipation of operations • Function standardization • Use of jigs
3	Streamlining all Operations (Internal and External)	• Rationalization of storage and transport of materials and tools • Implementation of parallel operations • Use of functional clamps • Elimination of final adjustments • Automation

The use of serious games can be considered as a type of active learning (Bonwell and Eison, 1991; Christie and Graaff, 2017). That practice is extensively applied at the Department of Production and Systems - DPS (School of Engineering, University of Minho, Portugal) and is characterized by quite positive results, not only in terms of trainees' motivation and engagement, but mainly regarding the knowledge retention aspect (Sousa et al., 2014). The DPS is significantly active in this area, and, among other activities, is involved in the Erasmus+ project 2016-1-PL01-KA203-026293 Innovative Learning Approaches for Implementation of Lean Thinking to Enhance Office and Knowledge Work Productivity (ILA-LEAN), along with other 3 universities (Poland, Norway and Finland) and 4 companies (Portugal, Italy, Norway and Poland).

As previously mentioned, the goal of this hands-on training session is to teach trainees how to implement SMED. In fact, the session is implemented as a serious game where 3 teams compete to achieve the fastest setup process.

2 Activities

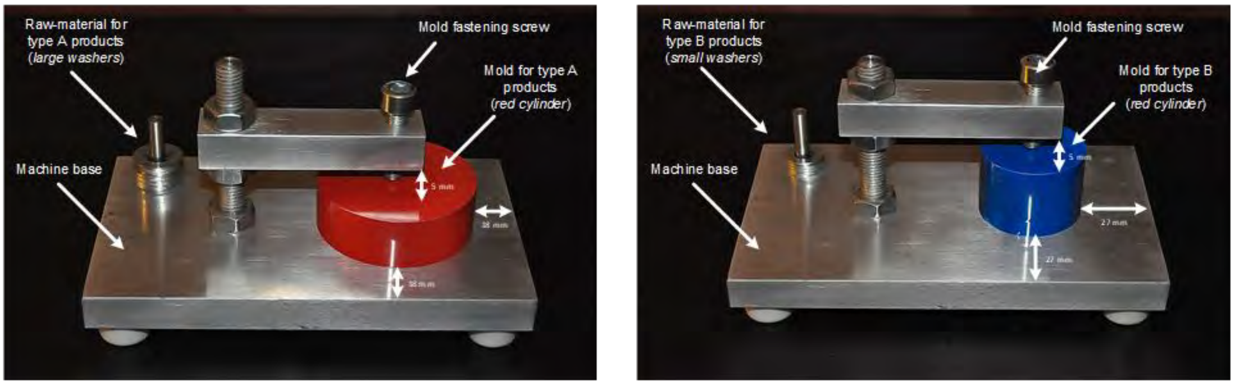
The session starts with a brief introduction to the SMED methodology. The trainees will be divided in 3 teams, each one with 3 to 6 members. Each team will receive the SMED kit – a set of physical elements including tools (Figure 1a)) and mechanical parts (Figure 1b)), as well as some paper sheets (e.g. check table for tools and setup operations registration sheet).



a) b)

Figure 1. The SMED kit a) tools b) mechanical parts

First, the trainees will observe the setup process executed by the trainer so they can understand, classify (external or internal operations) and measure (duration) the operations involved. Then, the 3 teams of trainees are instructed to perform the setup procedure necessary to change from the production of product A (Figure 2a)) to the production of product B (Figure 2b)) and they should register the corresponding duration. Next, the trainer conducts a discussion aiming to identify the main problems perceived by each team during the setup process. Taking into account those problems (the trainer also provides some improvement hints, e.g. the use of check tables and improvement of transports), each team should apply the SMED methodology and execute the second run of the setup process.



a) b)

Figure 2. Machine prepared for a) product A b) product B

After the second run, the trainer promotes a new discussion to analyse the achieved results and devise further improvement proposals. After this discussion, the trainer presents a radical improvement proposal (involving the “thinking out-of-the-box” concept) that leads to a dramatic reduction of the setup time. Finally, in the third run, each team executes the setup according to the final proposal, so they can confirm the expected results.

3 Expected results

After the hands-on training session, the trainees will understand the fundamental principles/concepts inherent to SMED and be able to apply the methodology to industrial scenarios. Despite its apparent simplicity, this hands-on session clearly illustrates not only the stages of SMED implementation, but also the application of almost all the techniques/tools inherent to this methodology (Table 1).

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Agile project management approach for engineering education: eduScrum™ workshop

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Abstract

EduScrum is an active collaborative education process that create an opportunity for students to make assignments according to a fixed rhythm. They plan and determine their own activities keeping track of their progress. The teacher "determines" the assignments, acting mainly as a coach and adviser. The event presents a path from teacher-driven education to student-driven and organized education. The teacher determines the Why and the What, the students determine the How. During the workshop a parallel will be drawn between scrum, education and applications in engineering education. The starting principles are the autonomy and authenticity of people. In eduScrum approach, students have to take responsibility for their own learning paths and work together independently. During the workshop, activities will be conducted to guide participants on the methods for team building and conducting the various stages of eduScrum. The expectation is that when passing through a guided experience, the participant understands in practice the various stages of the method. The objective is that at the end of the workshop, participants will be interested in trying out this student-centered methodology and looking for the necessary development of competences to apply eduScrum with their students.

Keywords: eduScrum; Active Learning; Project-Based Learning; Agile Approach; Engineering Education.

1 Introduction

To Ferreira and Martins (2016), eduScrum is based in the Scrum framework, but especially tailored for the education environment. Groups can be formed by students or the teachers can form the groups. Before each sprint, stand-up ceremonies and project planning take place. Mahnic (2012) states that during a sprint, which is a period of work, the group has to develop or solve a set of tasks or user stories related to the course's objectives. It ends with a sprint review, where the sprint results are assessed. To Scott, Rodriguez, Soria and Campo (2015) a course can be composed of several sprints, so there is no need for longer sprints, which are quite ineffective. Figure 1 presents an overview of eduScrum.

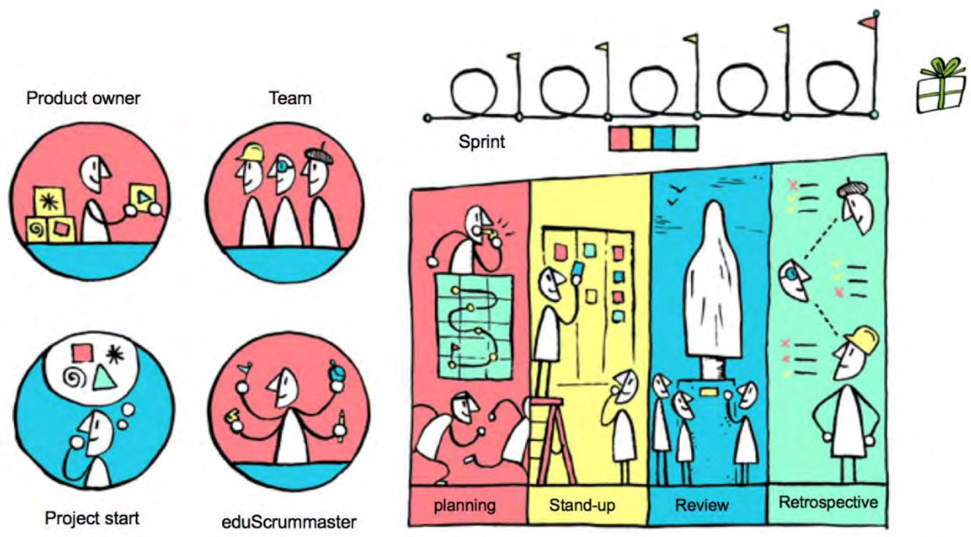

Figure 1 - Roles, sprints and ceremonies of eduScrum

For Dinis-Carvalho *et al*. (2017), an application of scrum with a pedagogical layer was proposed in 2013. Willy Wijnands is the initiator and founder of eduscrum and a chemistry/physics teacher on the Ashram College in Netherlands. Eduscrum uses the cerimonies, roles and tools of scrum.

With eduScrum, students work together in an energetic, targeted, effective and efficient way. eduScrum students are stimulated to develop into a valuable member of a team and ascertains a mindset that aims for constant improvement. This way of working generates pleasure, ownership, autonomy and responsibility, the work is faster and the results are better. In addition, students pass through a positive personal development and develop creativity, collaboration, communication and critical thinking (4Cs). A ground-breaking way of education, where personalized learning has a very important role.

2 Learning objectives

In this workshop, participants will:

- Discuss why the education must change.
- Get an explanation of the eduScrum process and the Why.
- Learn how to build teams and create an eduScrum approach.
- Pass through a guided experience in the eduScrum process hands-on.
- Reflect after working on a eduScrum case.

3 Activities

During the workshop, activities will be conducted to guide participants on the methods for team building and conducting the various stages of eduScrum. The activities will focus on the development of eduScrum planning. In this way, the construction of the product backlog, the definition of learning objectives from stories, time estimation, grouping of activities in sprints, the use of artifacts (flipboard and burndown chart) and script of the ceremonies will play a central role throughout the work.

Throughout the workshop, it is hoped to qualify the participants in the teaching competencies identified as priorities for eduScrum. Activities will be developed in 4 specific dimensions: eduScrum body of knowledge, lesson planning, class execution and writing of supporting texts.

The first dimension concerns the study and understanding of the philosophy behind the eduScrum and the guides and manuals developed by its proposer Willy Wijnands.

The second dimension involves applying the correct division of roles experienced by students and teachers, transforming learning objectives into user stories, and prioritizing planning, time and resources of instructional activities.

The third dimension encompasses efficient classroom workflow with the use of features such as the flipboard and the burndown graph. It also covers the grouping of activities in sprints and the management of deliveries and deadlines.

The last dimension concerns the transformation of class notes into self-instructional texts that allow the advancement of teams without the constant intervention of the teacher and thus give greater autonomy to eduScrum teams.

4 Expected results

It is expected at the end of the workshop that participants will be interested in trying out this student-centered methodology and looking for the necessary training to successfully lead eduScrum. The teachers involved in the event will form their own opinions on the usefulness of this approach with their own students.

5 Acknowledgements

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The EE Gospel - An Active Learning Workshop for Training Educators

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Abstract

It is well documented in the literature foundation that Entrepreneurship Education (EE) is a possible active learning strategy to better prepare engineering students for overcoming the working environment scenario and challenges marked in the beginning of the 21st century (Bygrave & Hofer 1992; Bygrave & Zacharakis, 2014; Gibb,1993; Gibb & Price, 2014; Johnson,1983; Brockhaus,1992; Filion, 1992; Borges & Filion, 2013, , Morris, Kuratko & Cornwall, 2013). Since its creation, in 1994, the Entrepreneurship Center Unifei (CEU) has launched several successful entrepreneurship development programs (EDPs). Its main objectives are entrepreneurship culture dissemination and regional development. With its pioneer spirit, the CEU has acquired a rich experience on EE, culminating with the creation of a specific EDP to share its knowledge with other education institutions, especially for educators: THE EE GOSPEL WORKSHOP. Throughout the last 6 years, the EE Gospel Workshop has already trained over 650 educators from around 24 educational institutions (universities, faculties, vocational colleges and primary or secondary schools) influencing directly around 4000 students. The EDP enables participants to utilize learning methodologies appropriated to develop and evaluate entrepreneurial skill in students. Adding to it, does not demand any extra disciplines or contents to apply due to its transversality, that is, any educator can make use of it independently of subject and/or knowledge area. The workshop proposes to share its experience by succinctly describing its main EDPs, presenting important concepts and tools related to EE applied transversally. At the end of the workshop, every participant should develop an implementation plan for his/her course(s) and/or discipline(s), independently of the knowledge area. Besides preparing educators for their courses and disciplines, EE Gospel workshop is given in a fashion that also aims the participant to become a new "DISCIPLE" prepared for replicate the methodology and therefore develop other trainers (educators).

Keywords: Active Learning; Entrepreneurship Education, Educators, Workshop.

1 Introduction

The end of nineties and the beginning of the 21st century have been marked by great market changes, acceleration of the innovation process, intense global competition and broad access to information. Such scenario culminates with the unemployment intensification that is considered one of the major problems faced by the capitalist economies. The great technological implemented by the manufacturing sector had generated immense improvement of quality and productivity; however, many job positions were extinguished. Moreover, many new opened employment positions cannot be filled quickly due to the lack of the demanded professional profile in the market. Several authors at the end of last century had already affirmed that education plays a great hole to overcome this scenario (Naisbitt, 1979; Tofler, 1997; Oliveira,1986; Fowler, 1994; Benett &Coshan, 1992). Nevertheless, the problem persists and it is unquestionable that professional development problems occur less or more intensely throughout the world (HP, 2010). More than technical skills in a specific area, it is desirable for the professional to present managerial skills as well as personal attributes such as: group work, leadership, human relations, creativity, adapting to change, ethics, honesty, learning to learn, working under pressure and motivation. Such attributes are also found in successful entrepreneurs. To act as an entrepreneur, in the business sense Lenko (1995) states that it is necessary to develop three sets of qualities, which are:

A) **Attitudes and Values**, as an opportunity for recognition, self-confidence and unraveling conventional wisdom;
B) **Human relationship skills**, communication, critical and creative thinking, decision-making, problem solving, management and organization;

C) **Knowledge of economic principles**, business world, marketing, production, finance, legal aspects, use of technological changes (p.19).

Several researchers recommend Entrepreneurship Education (EE) as a possible active learning strategy to better prepare engineering students for overcoming the working environment scenario and challenges. (Bygrave & Hofer 1992; Bygrave & Zacharakis, 2014; Gibb,1993; Gibb & Price, 2014; Johnson,1983; Brockhaus,1992; Filion, 1992; Borges & Filion, 2013, Morris, Kuratko & Cornwall, 2013).

Since its creation, in 1994, the Entrepreneurship Center Unifei (CEU) has launched several successful entrepreneurship development programs (EDPs).). Its main objectives are entrepreneurship culture dissemination and regional development in order to mitigate the challenges previously cited (Noronha, Fowler & Sant`Anna, 2017).

With its pioneer spirit, the CEU has acquired a rich experience on EE, culminating with the creation of a specific EDP to share its knowledge with other education institutions, especially for educators: THE EE GOSPEL WORKSHOP.

Throughout the last 6 years, the EE Gospel Workshop has already trained over 650 educators from around education institutes (universities, faculties, vocational colleges and primary or secondary schools) influencing directly around 4000 students. The EDP enables participants to utilize learning methodologies (Implementation of pedagogic changes) that involves students engagement and appropriated to develop and evaluate entrepreneurial skill in students (Development and assessment of competences). Adding to it, does not demand any extra disciplines or contents to apply due to its transversality, that is, any educator can make use of it independently of subject and/or knowledge area.

2 The Workshop (Contents, Structure, and Timeline & Agenda)

It is tailor-made and can be customized according to the restrictions of number of participants, infrastructure, and time. Nevertheless, it has its ideal form of implementation:

A) Number of participants (Minimum: 10 – Ideal: 50 – Maximum: 60);
B) Infrastructure: projector, audio system, white board and markers (or similar) for writing and appropriated room to enable the participants to work in small groups;
C) Time (Minimum: 2hs – Ideal: 4hs)
D) Contents & Agenda:
   a. Introductions & Definitions (sensitizing session);
   b. CEU-Our Experience & Results (you can replicate);
   c. Learning Styles (we are different);
   d. Seven Learning Technics (getting ready); and
   e. What Can I Do? (Now it is your turn to change).

3 Final Commentaries and Expected Results

This work does not intend to be a scientist article, that is, its main purpose is to introduce an workshop on entrepreneurship education to educators researchers interested on active learning methodologies as well as motive their interest on taking part of a workshop offered.

At the end of the workshop, every participant should develop an implementation plan for his/her course(s) and/or discipline(s), independently of the knowledge area. Besides preparing educators for their own courses and disciplines, the EE Gospel workshop is given in a fashion that also aims the participant to become a new "DISCIPLE" prepared for replicate the methodology and therefore develop other trainers (educators).

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Multidisciplinary Design Activities: a Framework for Training Lecturers

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Abstract

Planning multidisciplinary design activities in engineering courses can be seen as a promising process for promoting the integration between varied fields of study. Its effective use, however, is highly dependent on the lecturers team work and their ability to find multidisciplinary projects and activities that consider the learning objectives of each discipline.

This hands on proposal aims to provide lecturers with an opportunity to work on a multidisciplinary project in the role of theirs students: they are giving assorted materials and simple instructions (or even an inspiration context) in order to finish a task consisting of planning and executing a project.

The activity structure proposed here can be helpful as a framework guiding the lecturers' interaction and discussions regarding how to mix diverse subjects in one integrating task. Also, activities parameters like students requisites, time necessary for finishing the task as well as points where the creativity of students can play a role can be adjusted within the scope of the activity.

Keywords: Active Learning; Multidisciplinary Education; Lecturers Training.

1 Introduction

Recently, it has been emphasized the need to associate innovation, originality and creativity in all university curricula (Wince-Smith, 2006; Richter & Paretti, 2009; OECD, 2015; Morin, Robert & Gabora 2015). It is considered a significant part of the educators task of preparing students to participate in the innovation economy of the knowledge society. Regarding innovation, skills to be seriously considered as necessary are the ability to identify problems and possible solutions.

Teaching for creativity cannot be misunderstood with teaching creatively. Educators need structure in order to exercise their own creativity (teaching creatively) while the students potential for creativity can be better explored by freedom of rigidity and rules (Jónsdóttir, 2017).

It is the vision of the authors of this hands-on activity, that Problem-Based Learning, active learning and problem solving are key techniques to help educators prepare the structure inside which the students will explore with freedom.

In the process of evolving the framework of a PBL assignment, the lecturers need to prepare frameworks (problems, tools, methods, and so on) so that students have the experience necessary to evolve towards the goal skills and competence. Key points in this process are to decide how much is given and how much is let free to the students, as well as how to ascertain that the students achieve the goals (abilities and competences).

Usually, the framework is defined by the educator by means of a problem or situation to be solved, as it would be encountered by the students in a professional environment. However, as this refers also to examples mostly employed in traditional lectures, it can be seen as too rigid in terms of stimulating creativity. It can be suggested also, that when thriving for innovation, the identification of new problems are not particularly engaged when a particular problem or case is given, even if it is presented as a bad defined real world situation. In this sense, Ritter & Mostert (2016) have raised and suggested some creativity training or cognitive techniques to facilitate creative thinking skills and inspired the authors to consolidate the proposed hands on activity.

In order to provide a practical situation where innovation development is involved, the framework is defined by the materials employed and not by the statement of a problem. It is argued here that when some materials and tools are available, the skills and competence related to these components can be practiced. If further instructions seems to be necessary (for guiding the participants towards certain methods or techniques regarding these components), a theme or topic can also be useful.

This paper describes an experiment to illustrate an active learning intervention to be carried out with educators from different areas in order to experience a classroom situation constituted with students of different levels of knowledge. The experiment procedure is formatted to fit in a 160-minute hands-on session.

The experiment can represent an application in a class with students from different courses; in a group constituted for an integrated work with different disciplines.

The educators are induced to put themselves in the place of students when faced with an integrative activity with content that not all are familiar with a team they do not know. Reflections about the activity performed and the skills and abilities worked are carried out at the end.

The hands on session coordinators will be aided by two tutors (undergraduate students) and activity is prepared to be applied to a group of 20 participants divided into groups. Each group will receive a mystery box containing the materials to conduct the experiment and some guided information. It is designed, so that learners need work in a collaborative way, plan and execute de task and analyze the results, in this case, involving concepts related to Science, Technology, Engineering and Math. This hands-on session integrates a lot of the experience of the authors related in (Koike, Viana & Vidal, 2017).

2 Hands-On Session Goals

The session main objective is to provide lecturers and educators with an opportunity to experience a playful design situation where creativity and innovation are key points in the practice.

Apprenticeship goals are to practice active learning in a context where creativity and innovation are crucial. However, this session methodology also intends to be employed by the participant lecturers in their own classes. In this sense, the students goals are to train their abilities to identify potential problems related to the areas whose material is in the mystery box, as well as develop solutions to these problems.

Other goals are:

- Provide the opportunity for multidisciplinary within the same theme and restrictions;
- Inspire the lecturers to create their own practical sessions.

3 Methodology

The experiment development is based on collaborative teamwork and it is student-centered. The participants are divided into small groups. The teams are motivated to work autonomously with creative thinking. Problem-solving is held by planning and performing the experiment, noticing some driving context introduced with some resources (materials and information folder). The total time for the activity, 160 minutes, includes the discussion with all participants involved, and is established in terms of session time.

3.1 Material

Each mystery box is made of reused carton box (shoes or book box) and the material inside is a mix of papers, paints, glue, scissors, paper clips, and other stationery goods. Also, some technical material can be separated (inside small bags) with accompanying instructions (information folder), if necessary. Figure 1 shows examples of the contents of a mystery box. The technical material included was related to an electronic circuit with a multicolored led. In the same figure it is possible to see the collaborative teamwork after planning and splitting the tasks.

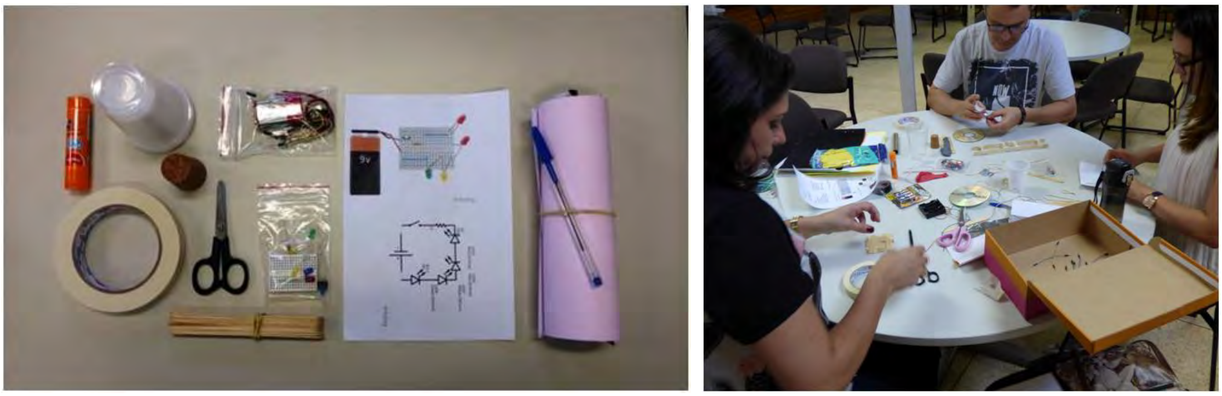

Figure 1. Example of the contents of a mystery box (left picture). On the right, a session collaborative teamwork.

3.2 Hands On Session Procedure

i) First of all, the participants are asked to organize themselves in multidisciplinary groups. The division of groups is made by some procedure using colors or numbers (10 minutes).

ii) A brief explanation about the session is given, stating the main goal and different phases during the session. Mysteries boxes were previously laid out on the work desks with the same theme for the projects (a poem, a song, an image, or a text.), and varied materials that can be used in the session. Not all materials need be used, but only materials in each the mystery box can be applied in the project. Some specific materials may be accompanied of instructions or illustrations to assist in their usage. The theme is not a problem, or situation explained, but rather an inspiration or a thread to be followed in the design (10 minutes).

iii) The participants are allowed to open the mystery box and engage, inspired by the theme, in the identification of a problem and its solution integrating the specific materials in the mystery box. The roles in each group should be divided among the participants, and each role should be given assignments in order to implement the solution (20 minutes).

iv) The groups are given 1 hour to implement the solution, and organize a brief presentation about the group work.

v) Each group is asked to present briefly the identified problem and the solution design, describing the implementation provided (30 minutes).

vi) The session concludes with a discussion about the pros and cons of the session methodology as well as ideas and insights about how to apply it on each lecturer/educator field of study (30 minutes).

4 Expected results

Although a single theme has been provided for all teams and the same materials have been distributed, it is expected original and creative works completed within the specified time frame and with the resources available in the mystery boxes.

From the results, discussion and ponderations will be realized on the validity of the experience, the skills and abilities worked, and the potential applications within the areas of the participants, including gains and difficulties that the students could find with these experiences.

Finally, it will be given to teachers the opportunity to experience in a playful way the process of creating new projects from suggested contexts.

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Active Learning Strategies – An Introduction

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Abstract

This workshop will present some fundamentals of Active Learning. We will also present some Active Learning strategies that have been widely used, mainly in basic and technical disciplines of the engineering and exact sciences programs of some Brazilian universities and in other countries. The strategies chosen to be presented at this workshop are: "Peer Instruction", "Flipped Classroom", "Just in Time Teaching", "Think Pair Share" and "One Minute Paper". This workshop is designed for participants with little knowledge about Active Learning strategies. It will be offered in Portuguese and may have up to 30 participants.

Keywords: Active Learning; Engineering Education; Strategies.

1 Introduction

As stated by Freire (2005):

> Teaching requires the conviction that change is possible.
> Teaching requires understanding that education is a form of intervention in the world.
> Teaching is not transferring knowledge.

Engineering instructors, in general, need to consider innovative pedagogical actions in their courses, designing and implementing new proposals for the processes of teaching and learning. Unfortunately, teaching in many engineering schools is still synonymous with presenting information. In this conception of education, the instructor's action is focused on content exposure, and students are listeners. In this sense, it is important in the current scenario, to provide a groundwork for studies and actions to enable changes of this paradigm.

Given these needs, what strategies and methods have the potential to develop skills required for future engineers? What aspects of teaching mediation need to be present in learning environments when the focus is on the occurrence of a meaningful learning? How to teach to develop structuring skills for the new millennium? How to mobilize the student to build their learning? What strategies and methods can enhance long-term learning and assist the student in developing higher order reasoning skills?

Teaching and learning processes, consistent with this trend, need to be increasingly focused on students' actions in situations that favor interaction, collaboration, knowledge exchange and the development of a meaningful learning (Ausubel, 2012). Active learning strategies can be a favorable means for knowledge acquisition.

Based on the work of many scholars of Active Learning (Bonwell & Eison, 1991; Meltzer & Manivannan, 2002; Prince, 2004; Mazur, 2015), this workshop will present some fundamentals of Active Learning and some Active Learning strategies that have been widely used, mainly in basic and technical subjects of engineering and exact sciences programs of some Brazilian universities and in other countries.

2 Activities

The activities in this workshop are:

(i) Getting to know each other.
(ii) Featuring some characteristics about our students today and those to come.

(iii) Discussing what participants understand by Active Learning.
(iv) Presenting the theoretical background of Active Learning.
(v) Sharing a sample of Active Learning strategies.
(vi) Developing an experiment with Peer Instruction.

3 Expected results

By the end of this workshop, we expect that the participants, that came to the workshop with little knowledge about Active Learning strategies, will be motivated to integrate some active learning strategies in their classrooms. It is well known that initial discomfort for both teacher and students will soon be replaced by much higher levels of energy and participation in classes, improved student problem solving ability, and improved communication skills, attitudes, and students' study habits. Thus, the instructor will able to develop in his students the lifelong learning skills, since they have learned to learn.

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Sustainability and Bibliometry as the main drivers of a PBL approach for a better understanding of Calculus1

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Abstract

Understanding the fundamental role of both, sustainability and mathematics in any engineering field as soon as possible is a must for engineering students. On mathematics, one major problem for engineering freshmen is Calculus1. Combining these two statements with a focus on engineering freshmen, as important as to know Calculus1 is to identify and characterize applications of its contents in sustainable projects. Synchronizing the learning of Calculus1 contents with the ability to search for possible sustainable applications of these contents in an Introduction to Engineering course configurate a possible initiative. These three dimensions (Calculus1, Sustainability, Introduction to Production Engineering) were used establish a PBL approach framework for a course offered at the Production Engineering Undergraduate Program of the University of Brasilia (UnB). This framework creates a tri-dimensional coordinate system (x,y,z): x for Calculus1 (x=1.Limit; x=2.Derivative; x=3.Integral); y for Sustainable Development (y=1.Environmental; y=2.Economic; y=3.Social); and z for Production Engineering Areas (z=1.Operations Engineering and Production Processes; z=2.Logistics; z=3.Operations Research; z=4.Quality Engineering; z=5.Product Engineering; z=6.Organizational Engineering; z=7.Engineering Economics; z=8.Work Engineering; z=9.Sustainability Engineering; z=10.Education in Engineering). All possible combinations of x, y and z create 90 possible cubes. A searching bibliometric methodology then works as a "machine" for filling these cubes with published scientific material encompassing Calculus1 contents in Sustainable Development aspects regarding Applications in Areas of Production Engineering. The students assigned to a team/cube prepare an initial analysis of the publications, going through the abstract, introduction and conclusion sessions. Publications of great relevance are object of further reading. This approach was implemented in the Introduction to Production Engineering course during 2017, with 80 enrolees in the first semester assigned to 18 teams and the 83 enrolees in the second semester to 17 teams. The discovery through mining bibliometric tools turned out to be an interesting case of active learning, while the effective delivery of the teamwork results is an example of a PBL approach. Just changing the z-axis contents, the same approach may be applied to any engineering program. This hands-on session aims at showing how the approach can be implemented in introduction to engineering courses. Proposal: (i)Groups definition; (ii)Model presentation; (iii)Bibliometry tutorial; (iv)Hands-on session for filling and analysing cubes; (v)Results presentation. Target: Introduction to Engineering teachers and undergraduate engineering students.

Keywords: Sustainability; Calculus1, Introduction to Engineering; Bibliometry

1 Introduction

Understanding as soon as possible the fundamental role of Sustainability in any Engineering field is a must. On the mathematical scene, one major problem for all engineering undergraduate programs freshmen is Calculus1. For them, as important as to know Calculus1 is being able to identify and characterize applications of its contents in sustainable projects.

Synchronizing the learning of the Calculus1 contents with the ability to search for possible sustainable applications of these contents as soon as possible was a challenging learning objective to be achieved through a PBL approach at the University of Brasilia undergraduate Production Engineering Program. The solution implemented was to take the Introduction to Production Engineering course offered as a required first semester course as the operational instrument. The first step was to divide the enrolees in groups. For effective teamwork, the groups went initially through a quick workshop session aiming at transforming the groups in teams. To each team was then assigned the task of finding, through bibliometric searching, as many as possible relevant scientific publications in terms of three dimensions: (i) usage of Calculus1 contents; (ii) aspects of Sustainable Development; and (iii) applications in the areas of Production Engineering.

For a bit of history, Chapter 7 (in Portuguese, "Projetos de Sistemas Sustentáveis de Produção no Curso de Graduação de Engenharia de Produção da UnB,) of the book published by Guerra, Rodríguez-Mesa, Gonzalez, & Ramírez (2017), describes the PBL approach adopted by the University of Brasilia Undergraduate Production Engineering Program. In this Program, the contents of Synthesis, Integration and Entrepreneurship, that constitute the fundamental pieces of the its curriculum structure, contemplate a Basic Nucleus of Concepts, eight Interdisciplinary Projects, two Graduation Project Courses, and a Required Internship. In most of the eight Interdisciplinary Projects, as well as in some courses in the Basic Nucleus of Concepts, is occurring an increasing usage of hybrid models, combining traditional and agile methods in project development. For several semesters, two courses of the Basic Nucleus of Concepts (Value Formation in Production Systems, and Production Systems Project Management) include publication reviews as activities developed as project teamwork. Starting in the first semester of 2017, the Introduction to Production Engineering course also include similar PBL approach. The big news for these three courses was the effective implementation of Bibliometric Searching applied to the Web of Science platform.

2 Description of the framework

In the first semester of 2017, 80 enrolees formed 18 teams, covering all Production Engineering Areas, except Education in Engineering. In the second semester the model was repeated in a class of 83 students and 17 teams. It is worthwhile to emphasize that the implementation of a social network is fundamental for the success of the activities.

2.1 Calculus1 contents

The syllabus of the Department of Mathematics of the University of Brasilia for Calculus1 states the following topics: Functions of one real variable, Limits and continuity, Derivatives, Integrals, Applications of Integrals.

2.2 Sustainable development

Sustainable development knowledge platform

According to Sustainable Development knowledge Platform(2015), the basic reference for Sustainable Development is the UN 2030, compassing 17 Sustainable Development Objectives: 1. No poverty; 2. Zero hunger; 3. Good health and well being; 4. Quality education; 5. Gender equality; 6. Clean water and sanitation; 7. Affordable and clean energy; 8. Decent work and economic growth; 9. Industry, innovation and infrastructure; 10. Reduce inequalities; 11. Sustainable cities and communities; 12. Responsible consumption and production; 13. Climate action; 14. Life bellow water; 15. Life on land; 16. Peace, justice and strong institutions; and 17. Partnerships for the goals. These 17 objectives can be seen in terms of three big titles: (i) Environmental; (ii) Economic; and (iii) Social.

2.3 Introduction to Production Engineering

According to the Brazilian Production Engineering Association (ABEPRO, 2014), the 10 Production Engineering Areas are the following: 1. Operations Engineering and Production Processes (OEPP); 2. Logistics (LOG); 3. Operations Research (OR); 4. Quality Engineering (QE); 5. Product Engineering (PE); 6. Organizational Engineering (OE); 7. Engineering Economics (EE); 8. Work Engineering (WE); 9. Sustainability Engineering (SE); and 10. Education in Engineering (EdE). With the exception of the Area 10 (Education in Engineering), that has a special meaning, all the other nine Areas may be and are treated as essentially operational.

2.4 Cubes for defining the teamwork contents

As shown in Figure 1, the contents of items 1.1, 1.2 and 1.3 above are used to create a tri-dimensional coordinate system (x,y,z), where (i) x stands for Calculus1 contents (x=1= Limits; x=2= Derivatives; x=3= Integrals); (ii) y for Sustainable Development (y=1= Environmental; y=2= Economic; y=3= Social); and (iii) z for Production Engineering Areas (z=1= OEPP; z=2= LOG; z=3= OR; z=4= QE; z=5= PE; z=7= EE; z=8= WE; and z=9= SE). All combinations of x, y and z create ninety possible cubes (x,y,z).

2.5 Bibliometric searching as a fourth dimension

Having the tri-dimensional framework shown in Figure 1 established, then comes Bibliometry as a "fourth dimension", working as a machine for filling the cubes created with published scientific material encompassing contents of usage of Calculus1 in aspects of Sustainable Development regarding Applications in Production Engineering Areas. For the publications in each cube, the next step was to prepare an initial analysis, going through the abstract, introduction, and conclusion sessions. Only publications considered of great relevance were object of further reading.

In order that the Introduction of Production Engineering course enrolees and now the participants of this hands-on session have the required background in bibliometric searching, two very simple tutorials, one in text and the other in video were prepared, covering all steps for a complete bibliometric search in the Web of Science platform.

3 Activities

The session starts with the creation of groups. As all material was prepared having the Production Engineering Undergraduate Program as reference, the groups will be formed in order to cover as many as possible of the Production Engineering Areas shown in the z-axis of Figure 1.

The second step is a brief presentation of the model, followed by a guided tutorial on bibliometric searching. As a result, at the end of the tutorial it is expected that many of the cubes will have some publications. Other publications will be found in a teamwork activity after the tutorial. The final step is to prepare and present a synthesis of the publications included in the corresponding cubes.

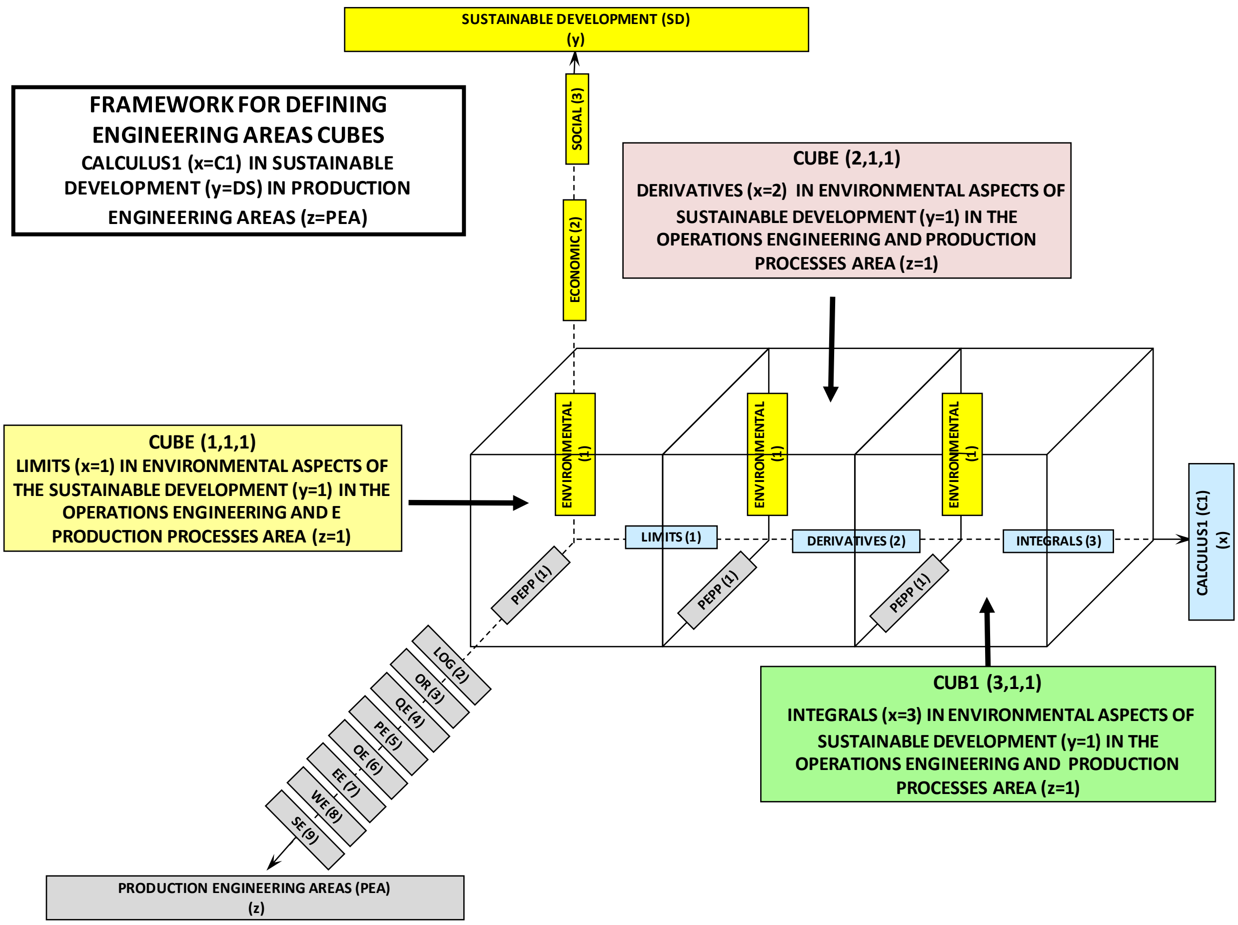

Figure 2. Tri-dimensional framework for defining cubes of project contents

4 Expected results

It is expected that the participants of this session, both engineering students and engineering teachers will be able to understand, and hopefully use, the tri-dimensional framework presented as a means to introduce Sustainability and Bibliometry as drivers of a PBL approach in Introduction to Engineering courses. Even though the z-axis components are directed to the Production Engineering areas, just changing the contents of the z-axis the same approach may be applied to any undergraduate engineering program.

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How to apply SCRUM in PBL teams

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Abstract

Scrum is a project management methodology very popular in the software industry with very good results in terms of team work effectiveness. Scrum is based on important team work values such as commitment, courage, focus, openness and respect and can be described in three different dimensions: Scrum team; Scrum Events; and Scrum artefacts.

This workshop aims to provide the participants with the opportunity to practice the scrum methodology. This goal will be attained by using a short project which includes similar characteristics to the typical PBL projects.

The first moment of the workshop will focus on presenting the basic concepts about the Scrum methodology, its use and main features. In the second moment the participants will be actively involved in a training activity which allows them to practice Scrum in a small project. This includes the generation of a backlog, a sprint planning meeting, and at least on sprint (one iteration of the methodology). The third and last moment will be based on the discussion and reflection about the effectiveness of this methodology when applied in PBL teams.

Some guidelines and tips for an effective use of Scrum in PBL teams will be available for all participants on the workshop.

Keywords: Scrum, Project management in engineering education, Teamwork in PBL.

1 Introduction

Scrum is the most known Agile Project Management approach adequate for managing software development (Sutherland, 2014) and it is designed for teams to breakdown their work into tasks that can be completed within a sprint (fixed duration cycles). This approach is inspired in the Toyota Production System and teamwork is one of its crucial elements. The teams should be of five to nine developers with help of a Scrum Master to maintain the methodology in action during the project. Figure 1 presents an overview of the Scrum framework with its main dimensions: team roles, ceremonies and artifacts (Schwaber & Sutherland, 2013).

Figure 1. Scrum framework (Neorain 2017).

The team is composed by the Scrum Master (a kind of project and team manager), Product Owner (representing the client) and team members. There three main ceremonies are: sprint planning, daily scrum and sprint review. The sprint planning takes place in the beginning of the sprint that can vary from one to 4 weeks of duration. In this sprint planning the team selects from the product backlog all the required tasks that can be performed in the next sprint. Every day the team meets (daily scrum) to evaluate how the work is flowing comparing to the plan and update the burndown chart (visual representation of the work done in comparison to the work planed). Possible decisions may be taken to solve existing lags. The spring reviews take place at the end of each sprint in order to overcome some problems. The team discuss what went well during the sprint, the problems that occurred and how they were overcome.

Finally, the Scrum approach includes three main artifacts, product backlog, sprint backlog and burndown chart. The product backlog, defined by the Product Owner, is an ordered sequence of everything that is necessary to the product. The product backlog evolves as the development evolves. The sprint backlog is the set of items from the product backlog selected to be developed during the sprint. The burndown chart is a graph showing how the work is evolving according to the plan.

2 Activities

This workshop will include a brief presentation about scrum and then the attendees will be challenged to experience a simulation of scrum environment including a single sprint. The workshop will last 3 hours in the following way:

Introduction (15 min) – Brief presentation about scrum with focus on its framework with focus on its framework, the basic concepts, its route, its use and main features.

Team formation (15 min) - The attendees will make groups of 3 to 5 elements and a project will be given to every group together with the following material:

- Project description; A scrum board template; A burndown chart template; A review sheet; Post-its; Pens

The teams are then guided to download a scrum poker app to install in their smartphones.

Planning phase (30 min) - The teams with the help of the Product Owner (the workshop organizer) will create the blacklog as well as the priorities. The team will then plan the first 60 minutes sprint (in reality should be of at least one week) using scrum poker to assign time to tasks and assign each task to team members. The burndown chart is prepared with the amount of time planned in the selected tasks.

Sprint (60 min) - Then the team members perform the required tasks and then at the end of sprint the team meet to review the sprint. During the sprint the post-its must be moved to "done" area. The burndown chart will be divided in 6 periods of 10 minutes each so it will be updated every 10 minutes.

Sprint review (30 min) - At the review meeting the team looks at the scrum board and reflects on how things that did note went as expected and take measures to avoid same mistakes in future. The next step is to plan the next sprint.

Open discussion (30 min) - Once everyone is familiar with the simulation an open discussion about the methodology will take place in order to clarify the use of this method in student projects.

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The Shanzu Case – an open online problem based learning platform

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Abstract

This is a hands-on workshop where participants work in groups with online learning material.

The aims of this hands-on workshop are twofold: The most important aim is to inspire other engineering educators to make use of problem based online case scenarios in their teaching, to the benefit of their students' active learning. A second aim is to assist the presenters in evaluating the prototype material and thereby assist in the process of improving the free and open access online learning material, for the benefit of engineering students and teachers around the world.

The agenda for the 90 minutes workshop is as follows:

- Introduction to the case scenario (5 min)
- Working with Module 1 of the online material (10 + 5 min evaluation)
- Working with Module 2 of the online material (10 + 5 min evaluation)
- Working with Module 3 of the online material (10 + 5 min evaluation)
- Working with Module 4 of the online material (10 + 5 min evaluation)
- General discussion on the usefulness of the online learning material (15 min)
- Evaluation of the workshop (10 min).

Expected outcomes:

- For the students participating: Gain a sense of real life engineering challenges in an unfamiliar context by working with the problem based online case scenario
- For the teachers participating: Become inspired to make use of online learning materials in their daily teaching
- For the workshop presenters: Gain valuable feedback on the prototype material in order to improve the free and open access online learning material to the benefit of engineering students and teachers around the world.

The maximum number of participants in the workshop is 50. Participants will work in groups of 5. Preferentially, all participants should have easy access to the Internet via a lap top, tablet or similar device. The ratio of students participating in the workshop should be between 50 – 70%.

Keywords: Engineering education, problem based learning, online learning, case scenario

PAEE/ALE'2018 HANDS-ON AND WORKSHOPS SUBMISSIONS (PORTUGUESE)

Submissions in Portuguese accepted for the PAEE/ALE'2018 hands-on and workshop sessions, characterized by being high interactive sessions in which participants and session organizers share their experiences and have common opportunities do develop competences to apply in their own practice.

Paper Planes Competition as Problem-Solving Methodologies Application and Prototype Developing

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Abstract

An important role of the engineering courses is the application of theoretical concepts in practical situations and the construction of prototypes to experiment and validate concepts. Ludic activities tend to promote good engagement of students.

We try to combine these characteristics in the proposal of an experimental class where students construct paper airplanes to participate in a competition that aims a flight, at the same time, long in time and distance. After initial free launches, students apply some problem-solving analysis tools, such as the QC-Story, Ishikawa Diagram and Design of Experiments (DoE) to seek improvement in their airplane design and initial results. Throughout the process several prototypes are built and applied scientific and structured methodologies by the students themselves in the search of winning the competition with the other colleagues. At the end of competition methods, analysis and result are compared among the students.

Keywords: Active Learning; Engineering Education; Problem-Solving; Project Approaches.

Competição de Aviões de Papel como Aplicação de Metodologias de Resolução de Problemas e Desenvolvimento de Protótipos

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Resumo

Uma parte importante dos cursos de engenharia é a aplicação de conceitos teóricos em situações práticas e a construção de protótipos para fazer experimentos e validar os conceitos utilizados. Atividades lúdicas tendem a promover um maior engajamento dos alunos. Neste artigo descrevemos uma forma de unir estas características na proposta de uma prática experimental, onde alunos constroem aviões de papel para participar de uma competição que visa um vôo ao mesmo tempo longo (em tempo) e distante. Após lançamentos livres iniciais os alunos aplicam algumas ferramentas de análise de solução de problemas, como o Método de Análise e Solução de Problemas o Diagrama de Ishikawa, a Análise Experimental de Variáveis para buscar aperfeiçoamento em seu projeto de avião até conseguirem melhorias com relação às marcas iniciais. Ao longo do processo são construídos vários protótipos e aplicadas metodologias científicas e estruturadas, pelos próprios alunos, na busca de vencer a competição com os demais colegas. Ao final da competição, os métodos, análises e resultados são comparados entre os alunos.

Palavras-chave: Aprendizagem Ativa; Educação em Engenharia; Resolução de Problemas; Abordagem por Projetos.

1 Introdução

Os trabalhos e atividades profissionais desenvolvidos na área de engenharia são, muitas vezes, conduzidos pela execução de projetos. O entendimento e aplicação de metodologias de planejamento, acompanhamento e execução de projetos é desejável na formação de engenheiros em suas diversas áreas de atuação.

Projeto de engenharia é um processo sistemático e inteligente no qual os projetistas geram, avaliam e especificam estruturas para equipamentos sistemas ou processos cujas formas e funções atendem os objetivos dos clientes e as necessidades dos usuários, enquanto satisfazem um conjunto de restrições especificadas. O projeto de engenharia trata problemas difíceis, pois esses geralmente não são estruturados e são abertos: Não estruturados, pois suas soluções normalmente não podem ser encontradas pela aplicação de fórmulas matemáticas e algoritmos de maneira rotineira ou estruturada; Abertos, pois normalmente têm diversas soluções aceitáveis. A singularidade, tão importante em muitos problemas da matemática e da análise, simplesmente não se aplica às soluções de projeto (Dym & Little, 2010).

Ainda se destacam em projetos de engenharia características inerentemente interdisciplinares, ou no mínimo multidisciplinares, criando a necessidade de desenvolvimento de trabalhos em equipes e demandando bom nível de comunicação entre os envolvidos.

Os aspectos teóricos de projetos e sua gestão são importantes na formação do engenheiro, mas ainda mais importante do que a teoria é a possibilidade de desenvolver práticas onde o estudante possa aplicar os conceitos teóricos, vivenciando projetos reais, em um processo que permite a sedimentação do conhecimento e gerando entendimentos mais profundos que possibilita a geração de competências e habilidades (Ânima, 2016).

Habilidade para projetar um sistema, componente ou processo para atender as especificações desejadas; Habilidade para trabalhar em equipes multidisciplinares; Habilidade para identificar, formular e solucionar problemas de engenharia e Habilidade para se comunicar eficientemente (Holtzapple & Reece, 2013) são algumas das características entendidas como necessárias no desenvolvimento de educação de engenharia -

Segundo critérios de avaliação e credenciamento de instituições de ensino de engenharia nos E.U.A. pela *ABET - Accrediting Board for Engineering and Technology*..

As atividades educacionais propostas neste trabalho buscam a criação de práticas vivenciais, onde conceitos e ferramentas são aplicados na resolução de problemas reais e os resultados podem ser avaliados pelos estudantes (Christensen & Eyring, 2014) e comparados com os resultados obtidos pelos demais colegas.

2 Competição de Aviões de Papel

A prática apresentada foi aplicada nas séries iniciais de cursos de Engenharia, na disciplina de Introdução à Engenharia e posteriormente na disciplina Laboratório de Aprendizagem Integrada, também foi aplicada para algumas turmas de 5º. ano na disciplina de Metodologia de Projetos, da Universidade São Judas Tadeu. Uma das preocupações iniciais ao desenvolver esta prática foi a proposta de uma atividade que fosse simples o suficiente para que os alunos a entendessem rapidamente, sem necessidade de um longo tempo para explicação do que se tratava o projeto e quais eram seus objetivos, sem a necessidade de uma alta carga cognitiva e que, ao mesmo tempo, permitisse aplicar os diversos conceitos e ferramentas necessárias para aprendizagem de como funcionam alguns aspectos de um projeto, sobretudo quando é necessário aplicar ferramentas de análise e solução de problemas. Também se procurou que durante o desenvolvimento e evolução do projeto, o aluno entendesse a necessidade e tivesse condições de construir protótipos para testar algumas hipóteses.

A construção de aviões de papel, atendeu as prerrogativas de facilidade de entendimento, de aplicação dos conceitos estudados e da possibilidade de construção de protótipos.

Junta-se a estas características o fato de ser uma atividade lúdica, que proporciona o engajamento dos alunos participantes (Goldberg & Somerville, 2010), pois além de ser uma atividade razoavelmente simples que todos conhecem (mesmo que em diferentes níveis), ao se acrescentar a componente de competição entre equipes, gera um nível de envolvimento que é difícil de se alcançar com outros tipos de atividades. Um aspecto relevante é que embora a atividade de aprendizagem tenha uma motivação de competição, mantém um alto nível de cooperação e trabalho em equipe dentro de cada grupo de alunos, favorecendo a aprendizagem entre pares (Mazur, 2015).

Outro aspecto de grande relevância no desenvolvimento desta atividade foi a busca por uma atividade de aprendizagem ativa, onde o aluno assume o protagonismo do processo de aprendizagem, usando processos cognitivos de ordem superior, desenvolvendo uma atitude autônoma, de descobertas próprias e responsabilidade (Biggs & Tang, 2011).

2.1 A Atividade

A proposta para os alunos é simples, em grupos (compostos por até seis alunos) eles devem produzir aviões de papel (com folha em formato A4) que devem contemplar duas características: Voar pelo maior tempo possível; alcançando uma grande distância.

Esta proposta traz em si um elemento dificultador para os alunos - o problema a ser resolvido, pois normalmente aviões que são arremessados com muita força tendem a atingir maiores distâncias, porém em um tempo é curto, pois são velozes, por outro lado, muitos aviões que ficam mais tempo voando, fazem acrobacias e, em geral, não alcançam grande distância (linear - linha reta de onde foi atirado até onde pousou).

Junto com a explicação do problema os alunos recebem um texto com dados de competições e premiações para voos de aviões de papel em ambiente fechado (mais próximo de uma sala de aula).

Após a explicação da proposta inicial e do objetivo do projeto, os alunos têm um tempo para pesquisas e testes livres, onde geralmente fazem os modelos de avião de papel que conhecem e começam uma primeira bateria de testes.

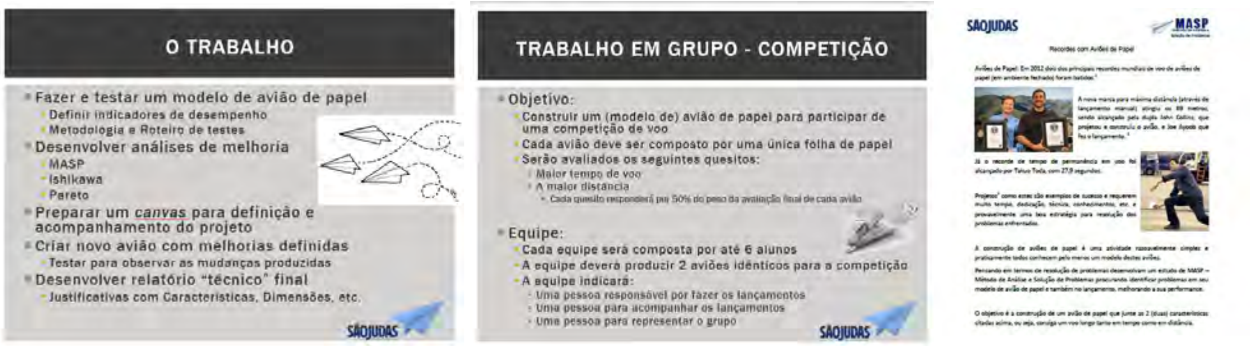

Figura 1. Instruções para Atividade de Competição de Aviões de Papel e Texto Orientador

Os alunos já estudaram antecipadamente os conceitos de projetos e de resolução de problemas, tendo conhecimento das ferramentas que serão aplicadas.

Cada equipe deverá ser composta por, pelo menos, os seguintes papéis: representante da equipe, que atua como um gerente de projetos; lançador, que é a pessoa responsável por fazer os lançamentos oficiais na competição e também alguém para realizar as medições e controles, que será o responsável por aferir os tempos e distâncias alcançadas pelos voos.

As equipes devem produzir dois aviões (iguais), sendo um para cada lançamento oficial. A ideia por traz desta solicitação é que os alunos provem que não chegaram ao acaso ao seu modelo de avião, e que conseguem reproduzir as soluções desenvolvidas para o problema.

2.1.1 Medições Iniciais

Após o tempo de testes livres, cada equipe apresenta seus colaboradores e produtos iniciais. As equipes fazem os lançamentos iniciais e anotam os tempos e as distâncias obtidas em suas duas tentativas (aviões distintos, mas de mesmo modelo).

2.1.2 Projeto

Com os dados iniciais obtidos, então tem início o projeto propriamente dito, pois agora a missão de cada grupo de alunos é melhorar sua performance, procurando ter o melhor desempenho entre todos os grupos. É nesta fase que os alunos aplicam os conhecimentos prévios e ferramentas que auxiliam na análise e resolução de problemas. Aqui são desenvolvidos diversos protótipos e testes, validando os aspectos teóricos aplicados e análises executadas. O resultado são dois novos aviões, que serão utilizados na fase final da competição.

2.1.3 Medições Finais

A entrega do projeto é composta por dois elementos, os aviões finais, obtidos após estudo e aplicação das ferramentas e técnicas de resolução de problemas, bem como a documentação correspondente.

A dinâmica de lançamentos de aviões e verificação de resultados obtidos é repetida. Agora cada grupo tem os dados iniciais e finais para comparar. Será gerado um relatório com análise tanto das marcas obtidas, como também da efetividade das ferramentas e avaliação da condução do projeto.

2.1.4 Documentação

Os alunos recebem um documento orientativo para entrega dos resultados e encerramento do projeto. Este documento traz dados e características do avião de papel, como por exemplo: dimensões, modelo e desenho técnico, mas também a justificativa de porque este modelo foi escolhido pela equipe, como suas características se adequam aos quesitos do projeto, bem como os demais documentos de análise utilizados durante a fase do projeto.

2.1.5 Comparação e Discussão

O encerramento da atividade é feito com a comparação entre os diversos resultados obtidos e discussão sobre as percepções dos alunos na condução das atividades e efetividade dos documentos e técnicas.

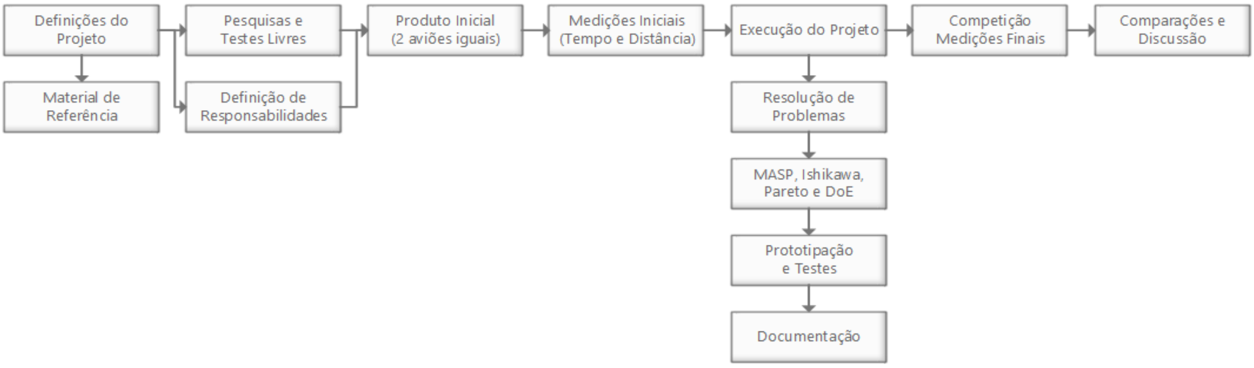

Figura 2. Sequência de execução do projeto

2.2 Resolução de Problemas

Uma vez que o grupo fez os lançamentos iniciais tem os parâmetros do projeto, que é a melhoria do avião de forma a ter uma melhor performance. Os alunos são incentivados a proporem um roteiro de testes e medidas a serem executados antes de partirem para a execução das práticas, de forma a planejarem soluções e as etapas necessárias para sua obtenção.

A ferramenta básica que será utilizada pelos alunos é o MASP - Método de Análise e Solução de Problemas, baseado no ciclo de Deming ou PDCA - *Plan, Do, Check, Act* (Kerzner, 2017). O MASP é um método estruturado em oito passos para resolução de problemas ou otimização de resultados. Os passos são: Identificação do Problema; Observação; Análise das Causas (que pode ser feito através da análise de um diagrama de Ishikawa); Plano de Ação; Execução; Verificação; Padronização e Conclusão.

Com o diagrama de Ishikawa os alunos conseguem relacionar as causas do problema com o efeito observado. Executado na metodologia "6 Ms" permite a análise em diversas esferas: Método; Material; Mão de Obra; Máquina e equipamentos; Medidas e Meio-Ambiente.

Desenvolvendo o diagrama de Pareto, os alunos conseguem entender quais das causas têm maior impacto no problema, categorizando, limitando e focando as ações corretivas nos itens que têm alguma relevância na solução do problema, descartando eventuais causas que sejam pouco significativas.

Por meio da aplicação da Análise Experimental de Variáveis (*DoE - Design of Experiments*) os grupos conseguem isolar e avaliar individualmente (e posteriormente em conjunto) o efeito de diversos aspectos do projeto, como por exemplo: O tamanho do avião, a gramatura do papel, a largura da asa, etc,

Figura 3. Documento modelo de orientação para desenvolvimento de documentação de projeto

2.3 Protótipos

Por serem de fácil confecção, os diversos aspectos estudados em um avião de papel podem ser construídos e testados. Assim os alunos desenvolvem experimentos e realizam testes reais, observando os efeitos de suas soluções nos diversos protótipos que são construídos ao longo da atividade.

A prototipação é uma fase importante no desenvolvimento de soluções de engenharia e por meio desta atividade os alunos entendem, de maneira ativa, como e porque fazer protótipos de suas propostas de soluções.

2.4 Canvas de Projeto

Aos alunos ainda é solicitado que desenvolvam um *canvas* de projeto (Finocchio, 2013) de maneira a visualizarem, avaliarem e discutirem as necessidades do projeto de melhoria de performance do avião de papel.

3 Resultados

A maior parte dos grupos de alunos conseguem melhoria no seu projeto, ou seja, conseguem fazer com que seus aviões voem por mais tempo e alcancem distâncias maiores, após a análise e solução de problemas e construção de protótipos. Também é observado que a performance entre os dois aviões finais de cada grupo apresenta resultados mais próximos entre si do que nas versões iniciais.

Grupo	Ti	Di	Tf	Df	% Tempo	% Distância	Resultado Final
1	2,27	3,17	2,26	6,6	-0,4%	108,2%	107,8%
2	4	10	2,18	8,4	-45,5%	-16,0%	-61,5%
3	1,17	7,83	2,96	9	153,0%	14,9%	167,9%
4	1,35	5,26	2,26	6,6	67,4%	25,5%	92,9%
5	2,53	7,17	1,89	7,8	-25,2%	8,8%	-16,4%
6	2,6	7	2	2,7	-23,1%	-61,4%	-84,5%
7	2,33	7	2,57	9,3	10,3%	32,9%	43,2%
8	2,53	8	2,03	3	-19,8%	-62,5%	-82,3%
9	2,4	12	2,94	5,7	22,5%	-52,5%	-30,0%
10	2,2	10	2,6	12	18,2%	20,0%	38,2%
11	1,56	10,3	2	6	28,2%	-41,7%	-13,5%
12	1,92	10	1,83	3,3	-4,7%	-67,0%	-71,7%
13	1,98	6	1,61	12	-18,7%	100,0%	81,3%
14	1,56	10,3	2,64	7,2	69,2%	-30,1%	39,1%

Figura 4. Exemplo de planilha de comparação de desempenho entre as medidas iniciais e as medidas finais

Embora os resultados sejam bastante dispersos, com desempenhos às vezes significativamente melhores e outras vezes piores do que na primeira tentativa, podemos notar que na maioria dos casos, os grupos focaram na melhoria de um aspecto (aumentar o tempo de voo ou a distância), visto que poucos grupos pioraram os dois resultados.

Mais do que o resultado em si, os exercícios de análise, de busca de soluções e de prototipação, buscando entender os mecanismos de voo e discutindo possibilidades, trazem em si um grande aprendizado. A avaliação realizada com os alunos na forma de discussão após a atividade (*debriefing*) e também os resultados obtidos em testes (provas) mostram que os alunos tiveram uma boa compreensão no uso das ferramentas de análise, conseguindo relacionar, comparar e integrar soluções em outras situações propostas

4 Conclusão

Aplicada algumas vezes, tanto com alunos iniciantes quanto com alunos em estágios finais de curso, esta prática gera um maciço engajamento dos alunos durante a execução da atividade, se mostrando acima da média, em termos de participação, quando comparada com outras atividades que ocorrem ao longo do semestre. A prática tem se mostrado eficiente e eficaz em termos de aprendizagem. O aspecto lúdico da atividade, somado à clareza nos objetivos, fazem com que os alunos se engajem no processo e percebam muito facilmente a importâncias da prototipagem e das estratégias de solução de problemas.

A extrapolação das ações simples de análise de solução de problemas para o mundo "real" é facilmente assimilada pelos alunos, mostrando que atingiram um nível de aprendizado profundo e significativo (Biggs & Tang, op. cit.).

Mesmo quando o resultado final não é melhorado (o avião de papel final, não tem um desempenho melhor), os alunos conseguem perceber quais foram os aspectos mais importantes na performance de seu protótipo, conseguindo fazer uma análise crítica de seu desempenho e possibilitando que tenham maior probabilidade de sucesso em projetos futuros. Os relatos dos principais pontos de impacto e possíveis soluções muitas vezes é indicado na conclusão da atividade, mas em outras ocasiões também fazem parte das discussões e comparações entre a performance dos grupos.

Também é percebido uma melhoria na habilidade de resolução de problemas por parte dos alunos, pois em algumas turmas são propostos outros projetos na sequência das atividades e, em muitos casos, é observado que os alunos passam a aplicar estas ferramentas e conceitos, mesmo sem que seja explicitamente solicitado que o façam.

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The Use of Design Thinking to Develop Skills and Competences Applying the PBL in Classroom

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Abstract

The job market in which our students will be inserted is increasingly dynamic and requires increasingly qualified professionals, not only conceptually but also knowing how to deal with their adversities. There is a need today to have a differentiated thinking in the academic community so that we can train students / professionals who are able to promote actions and carry out investigations, work in teams, manage problems and present solutions, as these are the new training requirements for a good performance in the labor market.

This workshop is aimed at training teachers who work with active learning using Project Based Learning as a methodology in the classroom. The PBL is a hand-in-the-box methodology that makes the student play a more active role in applying concepts in the development of projects and the teacher passes and has a role of being the tutor, the guide, guiding the student in the search for knowledge. Design Thinking is an approach that will be used so we can work on the skills and competencies that are developed when we use active learning.

The proposal is to present a project activity, hand in the mass and dynamic, to be worked in a group, that engages and motivates the participants and from this activity to apply the technique of Design Thinking for through discussions and development of the creativity, the participants can select the most important skills and competences to be worked on and developed in their classrooms.

It is hoped as a result of the end of the workshop that the teacher will prepare and present a plan of application of the PBL in its discipline going through all the steps that involve the methodology and have a clear vision of the skills and competences that will be developed in the students, structuring the work model.

Key words: Active Learning; Design Thinking, Project Based Learning

O Uso do Design Thinking para Trabalhar Habilidades e Competências Aplicando o PBL em Sala de Aula

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Resumo

O mercado de trabalho no qual nossos alunos serão inseridos está cada vez mais dinâmico e exige profissionais cada vez mais capacitados, não apenas conceitualmente, mas também sabendo lidar com suas adversidades. Há hoje a necessidade de termos um pensamento diferenciado na comunidade acadêmica para que possamos formar alunos/profissionais que sejam capazes de promover ações e realizar investigações, trabalhar em equipe, gerir problemas e apresentar soluções, pois essas são as novas exigências de formação para uma boa atuação no mercado de trabalho.

Este workshop é voltado para a formação de professores que trabalham com aprendizagem ativa utilizando o Project Based Learning como metodologia em sala de aula. O PBL é uma metodologia mão na massa que faz com que o aluno tenha um papel mais ativo ao aplicar conceitos no desenvolvimento de projetos e o professor passa e ter uma função de ser o tutor, o direcionador, guiando o estudante na busca do conhecimento. O Design Thinking é uma abordagem que será utilizada para que possamos trabalhar as habilidades e competências que são desenvolvidas quando utilizamos aprendizagem ativa.

A proposta é apresentar uma atividade de projeto, mão na massa e dinâmica, a ser trabalhada em grupo, que engaje e motive os participantes e a partir dessa atividade aplicar a técnica do Design Thinking para através de discussões e desenvolvimento da criatividade os participantes, possam selecionar as habilidades e competências mais importantes a serem trabalhadas e desenvolvidas em suas aulas.

Espera-se como resultado ao término do workshop, que o professor, elabore e apresente um plano de aplicação do PBL em sua disciplina passando por todas as etapas que envolvem a metodologia e tenham uma clara visão das habilidades e competências que serão desenvolvidas nos alunos , estruturando o modelo de trabalho.

Palavras Chaves: Aprendizagem Ativa; Design Thinking; Aprendizagem por Projeto.

1 Introdução

Em sala de aula o professor deve trabalhar não apenas os conceitos técnicos exigidos para a formação do estudante, mas como está sendo disseminado o aprendizado e quais as mudanças a que estes estão se propondo oferecer para seus alunos, desenvolvendo habilidades e competências necessárias nos dias atuais.

Estudos mostram que a percepção positiva dos alunos na realização autônoma de sua tarefa, quando há suporte docente, podem levar a aumentos na motivação intrínseca, auto-regulação, percepção de competência, interesse, engajamento e desempenho acadêmico (Stolk, J. At al, 2010)

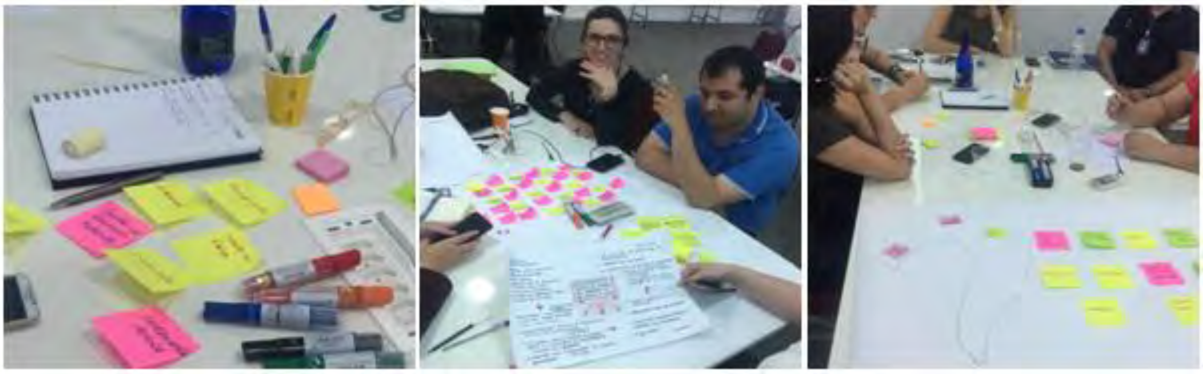
Surge a necessidade de pensamento e ensinamento diferenciado na comunidade acadêmica para que possamos formar alunos/profissionais que sejam capazes de promover ações e realizar investigações, trabalhar em equipe, gerir problemas e apresentar soluções, pois essas são as novas exigências de formação para uma boa atuação no mercado de trabalho.

Para isso é de fundamental importância formar os professores, através de programas de formação docente e workshops para que eles possam estar capacitados e em suas aulas propor práticas que ajudem no desenvolvimento de competências transversais e habilidades direcionando o aprendizado a ser mais ativo com características que são exigidas em um mercado de trabalho tão dinâmico quanto o que vivemos.

A utilização de métodos de aprendizagem ativa, tem uma grande intensidade de variação de acordo com sua implementação, incluindo abordagens diversas (Freeman,Scott, 2014)

Neste contexto a proposta deste workshop é oferecer uma oficina de treinamento com características mão na massa utilizando a Metodologia Ativa do Aprendizado Baseado em Projeto (PBL), para que possam transformar suas aulas e aplicar essa ferramenta. Dentro do contexto do PBL, será trabalhado também o Design Thinking para que o professor, possa se colocar no lugar do aluno desenvolver as habilidades e competências a serem trabalhadas.

Figura 3. Workshop mão na massa utilizando PBL e Design Thinking



Para obter os resultados esperados haverá uma dinâmica em grupo que possibilitará resultados práticos e discussões acerca de competências tais como:

1-) Competências de Gestão de Projetos: Capacidade de Investigação, Capacidade de Decisão, Gestão de Tempo

2-)Competências de Trabalho em Equipe: Autonomia, iniciativa, responsabilidade, liderança, resolução de Problemas

3-)Relacionamento Interpessoal: motivação e Gestão de Conflitos

4-)Competências de Desenvolvimento Pessoal: criatividade e originalidade, espírito crítico, auto avaliação

5-) Competências de Comunicação: comunicação escrita e oral

2 Activities

Neste workshop os participantes realizarão um dinâmica em grupo com o objetivo de construir um "Torre de Macarrão". Ao realizar esta prática, eles poderão interagir e a partir dos resultados por eles apresentados, será utilizada a Técnica do Design Thinking para que o docente possa se colocar no aluno e perceber quais as competências e habilidades foram trabalhadas pelo grupo.

Dessa maneira entende-se que isso pode ser inserido ao conteúdo programático e trabalhado com o discente em sala de aula dentro de uma disciplina.

O design thinking desenha o modelo de competência a ser aplicado em sala de aula.

Em seguida trabalha-se com o conceito do PBL, sendo este apresentado ao professor, quer tem por objetivo entender as suas e redesenhar sua disciplina, preenchendo um mapa em quatro etapas para a aplicação do o PBL em sala de aula, sendo Metas de Aprendizagem, Atividades a Serem desenvolvidas, Produto entregues e Avaliação

Assim, o professor poderá redesenhar o modelo de sua aula utilizando o PBL e pensando em atividades de projeto e avaliativas que permitam um melhor aprendizado do estudante.

Para viabilizar a atividade proposta é necessário que haja um número máximo de 30 participantes,e um mínimo de 5 participantes, sendo necessário ainda como recurso, uma sala que permita trabalhar em grupos de 5 participantes por grupo e datashow

3 Resultados Esperados

Espera-se que ao finalizar este workshop, o professor aprenda a utilizar as técnicas do Design Thinking em sala de aula para trabalhar habilidades e competência com os alunos. Também como resultado o professor deverá ter repensado seu modelo de aula e redesenhar uma disciplina transformando-a para ser trabalhada 100% em PBL ao longo de um semestre.

Com isso o docente será capaz de visualizar uma modelo de aula onde o aluno é o centro do aprendizado, coloca a mão na massa aplicando conceitos para desenvolver projeto e ter ganhos de aprendizagem prática e conceitual.

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Being a remarkable engineering teacher through communication? Yes, I can!

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Abstract

According to the literature, active learning strategies implies a change of the teachers' role, in terms of creativity to solve problems, collaboration with the staff, leading to uncertain situations and communication it is also a key competence in teaching practice. This workshop aiming at developing communication competences using a set of tools to improve the pedagogical relation between teacher and student. Three questions will be developed during the workshop: 1) "We teach who we are?" – participants will think about their professional identity; 2) "Can we teach without communicating?" – real situations will be provided in order to explore the importance of communication; 3) "Can we be a remarkable teacher?" – participants will be challenged to develop an action plan to make the difference in their teaching practice.

Keywords: Engineering Education; Teacher Practice; Communication

Tornar-me um professor extraordinário através da comunicação? Sim, é possível!

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Resumo

De acordo com a literatura, as estratégias de aprendizagem ativa reconfiguram o papel do professor, no que diz respeito à criatividade na resolução de problemas, colaboração entre docentes, lidar com situações inesperadas e a comunicação é também uma competência fundamental na prática docente. Este workshop tem como objetivo refletir sobre a importância da comunicação ao nível da prática docente, explorando e aplicando ferramentas capazes de potenciar a relação pedagógica. Três questões serão exploradas ao longo do workshop: 1) Ensinamos aquilo que somo? – os participantes irão refletir sobre a sua identidade profissional; 2) É possível ensinar sem comunicar? – serão apresentadas situações reais para que os participantes possam aplicar ferramentas de comunicação; 3) É possível ser um professor extraordinário? – os participantes serão desafios a desenvolver um plano de ação para fazer a diferença na sua prática docente.

Keywords: Educação em Engenharia; Prática Docente; Comunicação

1 Introdução

A aprendizagem ativa sugere a criação de experiências significativas em que o aluno é o protagonista na sala de aula, sendo responsável por aquilo que aprende, porque aprende e como aprende (Bonwell & Eison, 1991; Prince, 2004; Prince & Felder, 2006). Uma dimensão central é "com quem" os alunos aprendem e, por isso, o papel do professor é determinante na criação de experiências educativas verdadeiramente significativas (Christie & de Graaff, 2017).

Neste contexto, importa compreender o perfil do professor de Engenharia, ou seja, perante os contextos de ensino e de aprendizagem cada vez mais desafiantes e diversificados, quais as competências pedagógicas fundamentais ao nível do trabalho docente. Diversos autores apontam a comunicação como uma competência-chave no perfil do professor (Tigelaar, Dolmans, Wolfhagen, & Van der Vleuten, 2004; Zabalza, 2009). Ao nível da prática docente, a comunicação pode, efetivamente, acontecer em diferentes contextos e propósitos: transposição didática, concretização de material de apoio ao aluno, momentos de feedback, entre outros. Para Goldberg e Somerville (2014), a importância da comunicação reside na relação pedagógica, entre professor e aluno, passando por saber ouvir, fazer perguntas, apoiar em processos de decisão e desafiar os alunos a abrir possibilidades na resolução de problemas de engenharia.

Este workshop tem como objetivo refletir sobre a importância da comunicação ao nível da prática docente, explorando e aplicando ferramentas capazes de potenciar a relação pedagógica e, consequentemente, a aprendizagem dos alunos.

2 Atividades

Este workshop está organizado em três partes que, de forma complementar, visam criar oportunidades para os participantes refletirem sobre a forma como comunicam e a sua importância nos diferentes contextos da relação pedagógica.

A primeira parte tem como objetivo conhecer aspetos relacionados com a identidade profissional dos participantes, orientado pela questão: ensinamos o que somos? Para isso será realizada uma atividade de diagnóstico, com vista a que cada participante possa compreender que a forma como comunicamos está intimamente ligada com aquilo que somos.

A segunda parte é motivada pela questão: podemos ensinar sem comunicar? Neste momento, pretende-se explorar o impacto da comunicação no processo de ensino e de aprendizagem. Serão abordadas técnicas de comunicação que permitem potenciar a relação pedagógica em diferentes contextos, nomeadamente postura, escuta ativa, feedback e *backtracking*. Os participantes terão a oportunidade de praticar estas técnicas, em grupos de três, partindo de situações reais apresentadas.

A terceira parte visa a concretização de um plano de ação e, por isso, tem como mote: posso ser um professor extraordinário? O plano de ação é realizado individualmente e sugere uma mudança ao nível da prática docente no que diz respeito à comunicação. Neste sentido, o plano de ação considera os seguintes elementos:

- Objetivo SMART

- Ações a desenvolver

- Dificuldades identificadas

Após a concretização do plano de ação, haverá um momento de partilha pelos grupos (os mesmos da segunda parte do workshop), com vista a potenciar troca de ideias e experiências.

O workshop encerra com a apresentação das ideias principais abordadas e com recolha de feedback junto dos participantes.

3 Resultados Esperados

No final do workshop espera-se que os participantes sejam capazes de desenvolver um plano de ação que permita melhorar a forma como comunicam no contexto da sua prática docente. No plano de ação pretende-se que os participantes reconheçam a importância da comunicação ao nível da relação pedagógica e o potencial impacto no processo de ensino e de aprendizagem, particularmente em contextos de aprendizagem ativa.

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Making PBL teams more effective with Scrum

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Abstract

Scrum is a project management methodology very popular in the software industry with good results in terms of team work effectiveness. Scrum is based on important team work values such as commitment, courage, focus, openness and respect and can be described in three different dimensions: Scrum team; Scrum Events; and Scrum artefacts. This paper aims to analyse the implementation of scrum approach in a project based learning context in higher education. The scrum approach was applied in the fourth year of the Industrial Engineering and Management (IEM) degree program, where teams of students developed a PBL project in an industrial context during the first semester. The research methodology focused on a qualitative approach. Semi-structured interviews were carried out to the Scrum Team (scrum master, product owner and the student team). Scrum Events were analysed through direct observation and Scrum Artefacts (Product Backlog, Sprint Backlog and Increment) were analysed based on a document analysis. The results of this study contribute to understand the effectiveness of the application of Scrum to complex PBL learning environments. The results presented in the study provided important inputs to improve the way PBL student teams manage themselves as well as their projects.

Keywords: Project-Based Learning (PBL), Scrum, Project Management, Teamwork, Engineering Education.

1 Introduction

Project Based Learning (PBL) has been present in the Industrial Engineering and Management degree at the University of Minho for the last 10 years (Lima, Dinis-Carvalho, Sousa, Alves, Moreira, Fernandes, and Mesquita, 2017) with very positive results for most of the stakeholders (students, companies and university staff). The most worthy PBL experiences are the projects taking place in real context, usually in industry. One of the complex issues is the way student teams manage themselves and manage their projects. A very typical problem is that student teams end up having most of the work taking place just few days before the milestones (due dates defined for deliverables including final presentation and final report). The quality of the deliverables could be even better and student anxiety and stress could be reduced if student teams managed their work in more effective ways. The nature of these projects held in industry, complex and open, with unpredictable results, are virtually impossible to plan in reasonable detail, so traditional project management methodologies are not applicable.

Scrum itself is a simple framework for effective team collaboration on complex products (Schwaber, 2004) as well as being focused on managing projects where it is difficult to plan ahead, where feedback cycles are the core of the management technique that are used in opposition to traditional command and control management. Scrum is a project management methodology very popular in the software industry with positive results in terms of team work effectiveness and quality results. It is based on important team work values such as commitment, courage, focus, openness and respect and can be described in three different dimensions: Scrum team; Scrum Events; and Scrum artefacts.

The objective of this paper is to analyse how the Scrum methodology can be effective when applied in a project based learning context in higher education. This methodology was applied as the core project management methodology in two PBL teams in the fourth year of the Industrial Engineering and Management (IEM) degree program, where teams of students develop a PBL project in industrial context during the first semester.

2 SCRUM

Traditional project management is developed as a sequence of steps that the project team will perform. Most of the times, advancing from one phase to the other, requires that the previous phase is completely closed. This approach has several drawbacks, namely: the need to create a detailed and closed set of requirements at an early stage of the project; the client will have to accept the early negotiated results, even though he/she may want a different result at the end; project teams are most of the times separated by specific technical knowledge and this may result in integration problems.

In order to reduce these potential problems, during the 1990's, groups of project managers, mainly from the software industry, started developing new approaches. These approaches got a major boost in 2001 when seventeen experts of the software industry decided to meet to discuss the so-called "light processes". This leaded to the "Agile Manifesto", which stated the common values and principles of software production in an agile way (Beck et al., 2001). This manifest states the following values:

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

Scrum is the most known Agile Project Management approach. This approach is based in three main dimensions: team roles, ceremonies and artifacts (Schwaber & Sutherland, 2013). The team is composed of the Scrum Master (project manager), product owner and team members. There are three main ceremonies, sprint planning, daily scrum and sprint review. Finally, the Scrum approach includes three main artifacts: product backlog, sprint backlog and Burndown chart.

Sutherland (2014) refers, in his book, the opportunity to use Scrum for the improvement of educational results, describing some examples. The same author (Sutherland, 2012) refers the implementation of the so-called eduScrum in a school of The Netherlands (Delhij, Solingen, & Wijnands, 2015).

In the last years, the research community published a few papers on the implementation of Scrum approaches to improve learning in higher education. An example reporting better results on development of leadership competences obtained when students enrolled in the modified Scrum based class in an introductory engineering class (Stawiski, Germuth, Yarborough, Alford, & Parrish, 2017). Another example of the use of scrum in the classroom refers to the use of two pedagogical approaches, Lean Teaching and Learning and eduScrum, in engineering courses (Dinis-Carvalho, Fernandes, & Filho, 2017). Both approaches have characteristics of pull learning, with high student autonomy and responsibility. Finally, the authors present a set of recommendations for improvement of teaching and learning processes. Other works are focused on software related courses (Bruegge, Krusche, & Alperowitz, 2015; Mahnič & Časar, 2016; Rodriguez, Soria, & Campo, 2016), mainly associated to capstone projects.

The analysis of the literature showed that most of the publications that have simultaneously the term Scrum and education are related to the process of learning Scrum. The works referred in the previous paragraphs shows that, when Scrum is used with the intention to give support to the learning process, is mainly in software related courses. Thus, considering that Scrum is, nowadays, highly used and effective in project management practices, it is important to understand what could be the effectiveness of Scrum, if used in higher education courses, to support project-based learning.

3 Context of the Study

This study takes place in a Project Based Learning oriented semester in the fourth year of the integrated master's degree in engineering and industrial management at the University of Minho. This Project Based Learning (PBL) initiative involves all the curricular units of the semester and a company where the project takes place. Each team of students carries out a different project since a different company is assigned to each team of students. One particular curricular unit, designated as "Integrated Project in Industrial Engineering and Management II" (IPIEMii), assumes the leadership of the project and manages the communication between all curricular units, student teams, companies, tutors and teachers. The curricular units included in the semester are: (i) Manufacturing Systems Organization II, (ii) Integrated Production Management, (iii) Production Information Systems, (iv) Ergonomic Study of Workstations, (v) Simulation and (vi) Integrated Project in Industrial Engineering and Management II. Note that the last curricular unit mentioned is the result of the interaction between all the others and the company (

Figure 4).

Typically the objectives of the project of each team of students is to analyse, propose and implement improvements in specific areas of the assigned company. Throughout the semester students must develop the learning skills listed on the six curricular units directly involved in the project as well as other professional skills more linked to the real context project work.

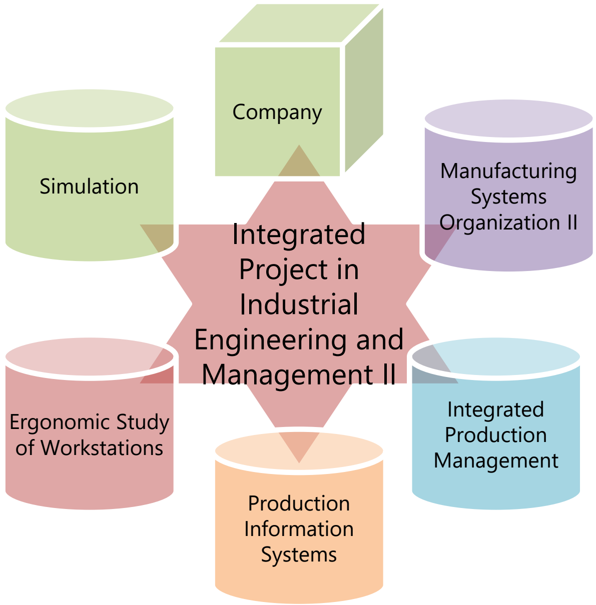

Figure 4 - Illustration of the interdisciplinary relationship between curricular units and the company.

During the project, students should characterize and diagnose the existing production system and evaluate its performance, identify waste, identify and model planning processes and production control, partially analyse how the implemented systems meet the functional requirements and the production system information and, create simulation models of the production system. Furthermore, students should also characterize workstations in the ergonomic point of view and their physical environment, and identify possible alternative actions and expected results.

The project is divided in three stages (Figure 5): (i) company exploration/recognition, (ii) analysis and diagnosis of the production system and (iii) improvement proposals; each stage's end was characterized by a milestone.

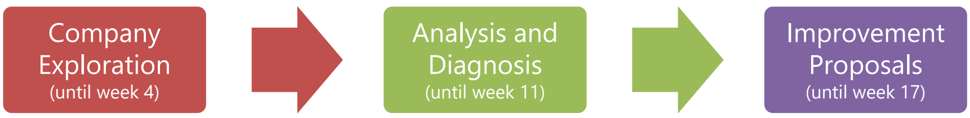

Figure 5 – The three stages of the project.

The PBL organizers encourage the student teams and company representatives to strive to implement the improvement proposals but it is not compulsory for the project approval. Ideally the improvements should be implemented within the semester but in many cases the improvements are implemented afterwards and in some cases the improvement proposals are never implemented.

3.1 PBL project with Scrum

This paper reports a study conducted in the last edition (2017) of the PBL project, briefly described above, where two teams of students applied Scrum as a tool to help them manage the project and the team. In this particular edition the number of students taking the course reached the highest number ever, forcing the teams to accommodate 10 and 11 elements. Teams with so many elements are a problem in many ways. It is a problem for companies in managing so many external people walking around their shop floor, it is a problem for the university to find physical space where teams can work and all the problems related to team and project management. The need for effective project and team management techniques and methodologies is becoming more and more remarkable as the student team size is increasing.

The Scrum methodology makes a lot of sense in PBL environments since many dimensions of the projects are unpredictable. In most cases no one knows how the project will evolve. Neither students nor most companies have any experience with this type of projects and therefore little knowledge exists about what will happen. The projects are evolving as they happen, depending on feedback from companies, feedback from teachers or from unexpected restrictions.

A bounded space in a room with tables, chairs, lockers and boards is assigned to each student team to work on the project and maintain their boards with information and other project related material. A board was assigned to keep scrum information in both teams that adopted scrum methodology.

3.2 Scrum Teams

From the existing 6 teams in the PBL project semester, two teams were randomly selected to adopt scrum methodology as the main project and team management methodology. The selected teams were briefly trained on the main features of Scrum and a teacher was assigned to both groups to play the scrum master role. A teacher playing the traditional tutor role is always assigned to each PBL team but in this case a teacher with motivation and some degree of Scrum knowledge was assigned to play the Scrum Master role. The Product Owner role was performed by the responsible for the "Integrated Project in Industrial Engineering and Management II" course. Regarding the sprint length, both groups decided upon using sprints of one week period. Both groups also decided to have the review meeting on Friday afternoons, followed by their sprint planning meeting. The initial plan was for them to have the sprint planning meeting on Mondays but because they couldn't manage to meet on Mondays, due to lectures that they must attend that day, they decided to have the sprint planning meeting at the end of the Fridays, after the review meeting.

3.2.1 Student Team 1

Student team 1 was composed of eleven elements (9 male and 2 female) and the project assigned to the team takes place in an aluminium foundry company. The main objectives of the project were to analyse the production reality (production flows, layout, performance indicators, training, human factors, production information systems), identify problems and improvement opportunities and draw improvement actions and implement them. The company assigned the continuous improvement coordinator as the liaison person to supervise, guide and help the student team in the company.

3.2.2 Student Team 2

Student team 2 was composed of ten elements (8 female and 2 male) and the project assigned to the team takes place in a company that produces wiring systems for tractors. The company in reality proposed two projects. The objective of one project was to analyse and implement improvements in a particular assembly cell and the other project was to map an existing process an introduce improvements. The existing process was the set of the existing steps necessary to result in a new prototype solution that could fulfil in the best possible price the specifications of a customer. The team decided to assign some team members to one project and other team members to be focused on the other project. The company assigned the production manager as the liaison person to supervise, guide and help the student team in the company.

4 Methodology

The research methodology focused on a qualitative approach. An online survey, applied at the initial phase of the project, was used to collect data from the two teams using the Scrum method in the project. Besides this, direct observation of team meetings and teamwork developed in the project rooms, informal conversations with students and the team tutor and a document analysis of the scrum events and artefacts were included in the analysis.

Students' expectations were collected through an online survey, which included five open ended questions and one closed question. The questions included the following:

1. What did you like most about Scrum?
2. What did you like least?
3. How do you expect Scrum to help you with the project management?
4. What are the difficulties that you expect to find with the use of Scrum?
5. If you had to explain what is Scrum to a friend, what would you say?
6. In general, how useful do you find Scrum? From 1 (little useful) to 10 (very useful)

In total, 14 students answered the survey, during the first two weeks of October 2017. This corresponds to the initial phase of the presentation of the Scrum method by the tutor (scrum master) to the two PBL teams involved in this study. After this phase, the teams started to implement the Scrum method and regular visits, by the researcher, the team tutor and the PBL staff members were made to observe the teams working in the project rooms. Data reported in this study refer to the first half of the semester of the PBL approach.

5 Preliminary Results

The following sections present the preliminary results based on students' initial perceptions about Scrum and a brief analysis of some of the scrum events and artefacts.

5.1 Students' initial perceptions about Scrum

As a result of an online survey applied to the two PBL teams using the Scrum methodology to manage the project and the team, the following categories were organized.

5.1.1 What is Scrum

When asked to describe what Scrum is, students identified several characteristics about the method such as: planning, organization, defining tasks, setting goals, time management, team management, weekly sprints, individual responsibility, etc. Students' answers illustrate their views in regard to what are the main components of Scrum, such as presented in the following quotes.

> *"Method for group work, which aims to plan tasks to be developed, especially in short term. Tasks are defined based on the individual competencies of each team member. The task planning results from a process of brainstorming. Scrum is always followed by sprints – weekly meetings, in this case – where an evaluation of the week is made, reflecting on what went well, what went wrong and what could be improved, etc."*

> *"Set long term goals and tasks, to be attained in short term. The information is organized on a board that is continuously updated."*

> *"Task and time management tool."*

> *"There are weekly Scrum meetings with the aim to define the tasks to be developed. As new tasks arise, each team member defines, confidently, a specific time necessary to complete this task. Through this method, it is possible to verify if each team member understood the task. The sprint is defined (tasks to be developed during the week), according to the available hours in the week. In the following week, a reflection on the sprint is done and a new sprint will be planned."*

In general, the students seem to have an idea about what the scrum method is in terms of sprint planning, showing great concern with the issues related to the definition of tasks and the deadlines for their accomplishment. This concern is quite natural, as mentioned previously in the literature review section, where the need to create a detailed and closed set of requirements at an early stage of the project is presented as one of the drawbacks of project management.

5.1.2 Most / least positive about Scrum and difficulties expected

Most of the students were aware of the advantages of Scrum, as they identified positive aspects which they liked about the Scrum method. The most positive aspect mentioned by students was task management. Linked to this topic, is the definition of deadlines and the weekly planning, which are interrelated (see table 1). It is clear that students understand the objectives and procedures of the Scrum method, as they also mention that these were simultaneously some of the issues that they liked less about Scrum, probably due to the difficulties found in the implementation process and the lack of experience in using this method. Some students referred that the Scrum method was a "waste of time". Some explanations to understand this point of view were explored in the informal conversations with students, during the visits to the project rooms. The arguments were mainly related to the difficulty in defining the duration of each task, one of the requisites for defining a weekly sprint. While still not being aware of the advantages and potential of the time spent on the planning phase in order to successfully achieve the objectives of the sprint, the students found this aspect as one of the most critical issues of the Scrum method.

Table 1: Students' perceptions of the most positive and least positive aspects about Scrum

Most positive about Scrum	Least positive about Scrum	Difficulties expected
Organization of tasks (7)	Waste of time (4)	Definition of the duration of tasks (6)
Defining deadlines (4)	Planning of the Sprint (3)	Sprints (2)
Weekly planning (3)	Definition of the duration of tasks (3)	Meetings (2)
Team management (3)	Meetings (2)	Accomplishment of tasks
Visual management (2)	Applying the burndown chart	Lack of time
Sprints (2)	Not useful	Managing other "extra" tasks
Burndown chart		Scrum board
Reflection		Rapidness
Team motivation		

5.1.3 Scrum to support project management

In the PBL approaches carried out at the IEM program, students must develop a project, in teams made up of 9 to 11 students, during a semester. The projects are developed in interaction with industry and students must keep up with a set of *milestones* defined by the PBL staff coordination team. Considering the demands of this active learning approach, the volume of tasks necessary to attain the project's objectives and the limited time available to conclude the project (one semester), the use of Scrum is a valuable tool to support project management.

According to students' answers, Scrum will support the team in the project management process by providing a better organization of the team, a better planning and management of tasks and also the fulfilment of deadlines in the stated dates. Individual responsibility is also enhanced through this process. The following quotes from students confirm this.

> *"It helps the organization of work. There is no doubt about that. The fact that we analyse problems and transform them into tasks and, at the same time, we make each member responsible for the achievement of each task, in the timeframe of a week, encourages the team to work effectively. Setting goals to keep up with this method is, in my opinion, an encouragement for the group".*

> *"It encourages personal organization and fulfilment of deadlines, resulting in a better management of the project".*

> *"Since there are many members in the team, the use of Scrum helps to keep the team focused".*

> *"I hope it helps the team not to procrastinate and to be more organized and work as a team".*

Other topics were also mentioned, referring to the role of Scrum in the project management process, such as visual management tool, team motivation, weekly planning, group cohesion, project monitoring, avoiding procrastination, etc.

To complete this analysis, results from the single quantitative question included in the online survey can be crossed with this question. The majority of students classified the usefulness of Scrum, on a scale from 1 to 10, with classifications above 7 (13 out of 14 answers). The average was 7.76. Only one student considered Scrum of little usefulness, attributing the classification of 3 for this question. However, this result does not seem very worrying, considering the overall classifications.

5.2 Analysis of Scrum Events and Artefacts

The scrum event that was more important in both groups was the sprint planning (see 3rd column from the left on Figure 3). Although in the beginning most students did not see its value, as they were gaining experience in defining the tasks, they became more and more aware of its effectiveness. The scrum master played an important role in maintaining the students focus in defining the tasks in the most clear and possible way. The students realised that the time spent in defining the tasks in detail, its workload and responsibility gave them the advantage in achieving very good performance every week. In the beginning, one group had the temptation of defining small number of big tasks instead of large number of small tasks as if it would save some time in planning. Later they learned that the execution of such big tasks was difficult to predict and the results were bad.

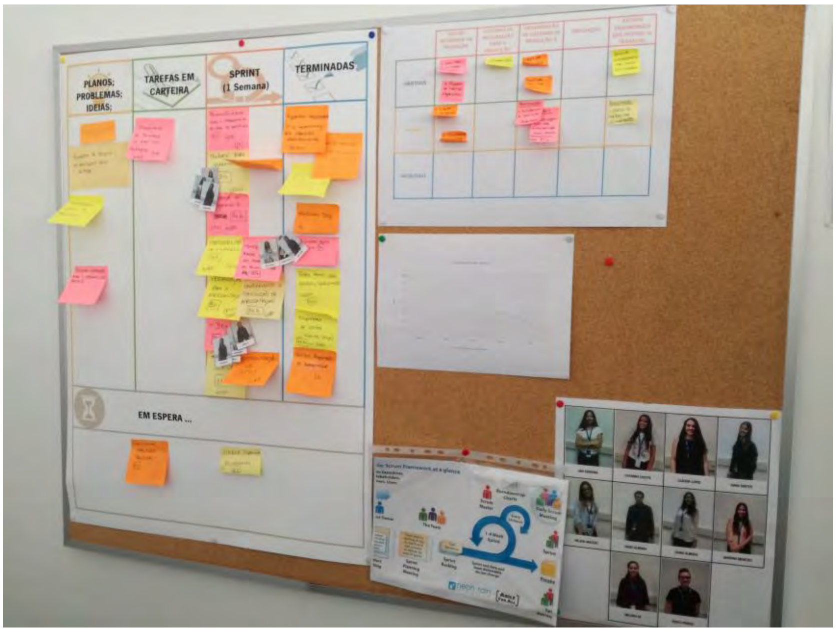

Figure 6 – The scrum board of one team.

The Backlog was something that neither group really grasped maybe because they knew little about the end results expected in the project. Since the company did not define very well the expected deliverables, the students don't see advantages in creating a backlog. This is one of the issues that must be developed in future PBL editions.

The burndown charts were created in every sprint planning meeting according to the man-hours available and the amount of hours required for the planned tasks to the next sprint and then updated as tasks are completed. The sprint reviews played an important role in the success of the scum adoption since many problems were founded and avoided in the next sprints (see upper right side of the board in Figure 3).The burndown charts had a particular characteristic in this experience since the number of man-hours available each week varies from week to week and the team had to assign tasks that could fit the available capacity of the following week. This dynamic aspect of their reality gave them the need of making very detailed planning. An example of a burndown chart is shown in Figure 4 where it is clear that on Wednesday they perform most of the work because is on Wednesdays that they do not have any classes and they spend the day doing project work.

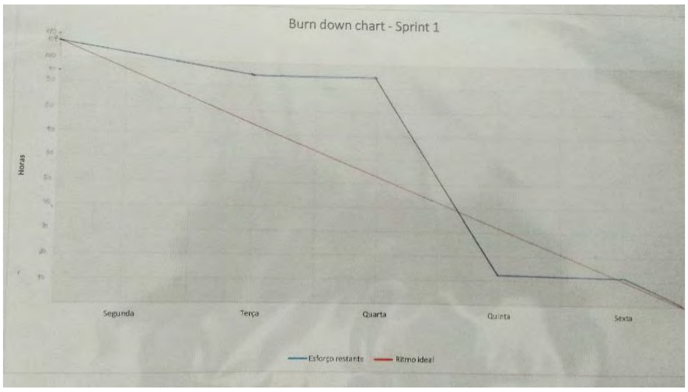

Figure 7 – One example of a burndown chart.

The sprint planning became so important for one of the groups that some students confessed that they could not manage their project without it. They also said that they take pictures of the board so that they can have a look at it when they are not in the room, and that shows how much they became dependent on it.

6 Final Remarks

In this paper, the Scrum methodology was explored in the context of PBL teams to analyse its effectiveness to improve team performance and project management. The specific characteristics of the PBL approach carried out in the fourth year of the IEM project, where the student projects are developed in articulation with a company, based on complex and open problems, show the importance of effective project and team management techniques and methodologies, as many dimensions of the projects are unpredictable.

The objective of this paper was to describe the implementation of the Scrum methodology as the core project management methodology in two PBL teams. Findings collected from the participants involved in the study (student teams, scrum master and project owner) provided a positive view of the overall impact of the use of the Scrum method. As most positive, students refer to the advantages of Scrum for weekly planning, task management and definition of deadlines. The difficulty in defining the duration of tasks was one of the main problems found, probably due to the lack of experience of students in using this method. However, after getting acquainted with the method and the sprint planning, one of the teams admitted that the Scrum method was truly effective for project management and that the team felt highly committed to its use.

In general, the results of this study contribute to understand the effectiveness of the application of Scrum to complex PBL learning environments. The results presented in the study provided important inputs to improve the way PBL student teams manage themselves as well as their projects.

7 Acknowledgements

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Interdisciplinary medical projects by engineering students: challenges and learning opportunities.

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Abstract

Employers, students and tutors agree that experience gained during real-life projects is very valuable to prepare engineering bachelor students for their professional career. Nowadays, various disciplines working together within complex projects is common practice in industry and research institutes. Moreover, many engineers work in an international environment, working together with colleagues with different backgrounds.

In this paper, the experience with three award-winning student projects will be described. Medical doctors commissioned these projects that were performed by bachelor students from various engineering programs. This resulted in specific project challenges for the students and tutors. This paper describes these challenges and the many learning opportunities recognized by students and tutors. The projects described in this paper also show examples of the vast possibilities of 3D printing.

With this paper, the author aims to inspire other tutors to continuously improve Project-Based Learning for engineering students and to incorporate long-term interdisciplinary projects in the curriculum.

Keywords: Project-Based Learning; Engineering Physics; Medical Projects; Interdisciplinary Projects.

1 Introduction

With more than 44,000 students and 4,300 employees, Fontys University of Applied Sciences (Fontys) is the largest public knowledge institute in the southern Netherlands. In the city of Eindhoven, various Engineering programs can be followed that lead to the international Bachelor of Science degree. Fontys offers some of these programs in English (Fontys, 2017). Every engineering program is designed to prepare the students for their future work field. For example Electrical & Electronic Engineering, Mechanical Engineering, Mechatronics Engineering (together abbreviated as EEMM Engineering) and Engineering Physics. This paper is written from the perspective of Engineering Physics.

2 Engineering Physics

In the Netherlands, Fontys and two other universities offer Engineering Physics on bachelor level. It is a four-year program to become a starting professional. Together these universities have defined a list of nine competences, mainly based on two European documents. First, the learning outcomes on level 6 as described in "The European Qualifications Framework for Lifelong Learning" (European Communities, 2008). Secondly, the competences and achievements that physics bachelor graduates should have acquired as described in "A European Specification for Physics Bachelor Studies" (European Physical Society, 2009).

For all nine competences, the three universities compiled a list of characteristic activities, by which the starting professional proves to be competent. Following the program, the students will grow from the level of "executing", via "solving" to "integrating".

As stated in (European Communities, 2008) project work should be a significant part of the curriculum.

> *"Independent project work should be used to facilitate the development of students' skills in research and planning (..) and to enhance their ability to assess critically the link between theoretical results and experimental observations."*

Although all nine competences are relevant within Project-Based Learning (PBL), the most important competences are “Performing research to solve a problem” and “Develop, improve, or implement products or processes”. In Table 1, examples can be found of the characteristic activities for these two competences.

Table 1. Characteristic activities for the two competences most important for Project-Based Learning.

Competence	Level	Examples of characteristic activities
Performing research to solve a problem.	executing	Clarify the research question.
	solving	Formulate the research sub-questions and explain the research strategy.
	integrating	Define the research strategy based on the research question.
Develop, improve or implement products or processes.	executing	Apply the criteria a product or process needs to fulfill.
	solving	Where necessary, adapt the criteria a product or process needs to fulfill.
	integrating	Compile the list of criteria a product or process needs to fulfill.

3 Project-Based Learning curriculum

Projects and internships play an important role in the curricula of all Fontys engineering programs. It gives the student the opportunity to learn while solving real-life problems (Graaff & Kolmos, 2007). In this section, the PBL curriculum of the Engineering Physics program will be described. The PBL curricula of the other engineering programs are largely similar.

The first-year Engineering Physics students work in project teams of eight students and the projects last two to three weeks including start-up, report writing and presenting the results. The content of these first-year projects is largely predefined. The main goal is to learn to work in a structured way on complex practical problems. The students learn to integrate theoretical knowledge with various practical and soft skills. During these first-year research and design projects, the tutor not only supervises and assesses the students, but also acts as the project owner.

For second- and third-year projects, an imaginary engineering firm has been created. Anyone from within Fontys or from outside, can submit questions and commission a project. When suited for our students, the tutor writes a project proposal in cooperation with the project owner. For the first time, students must deal with an actual project owner and the students learn to clearly present their plans and progress. Every second-year student performs two projects, which take ten weeks each. The final results are presented to the project owners, students and tutors during an internal symposium.

During the first half of their third year, the students will complete a full-time internship lasting 20 weeks in a company or institute. The students get day-to-day guidance from within the company or institute. A tutor from the university will guide the student from a distance and will keep an eye on the level of the work and the quality of the report. For most students this first internship shows that they can individually deliver a contribution in the real world. This motivates the students to finish their education and gives a clear picture of the skills needed to become a professional.

During the second half of the third year, an interdisciplinary project is planned. In project groups of five to eight students from several engineering programs, each student spends 220-280 hours on the project for twenty weeks. At the end, all projects are presented during the Fontys Engineering and Natural Sciences Symposium, which is open to the public.

Representatives of the "The Royal Netherlands Society of Engineers" (KIVI, 2017) assess the reports and the presentations of the interdisciplinary projects, which have been nominated for the yearly KIVI-award. Tutors can nominate projects, based on the quality of the work done and the results achieved. One of the conditions to be nominated is that the report and the presentation are in English. In total 42 projects were presented during the symposium in 2017 and seven of these projects were nominated for the 2016-2017 KIVI-award.

The challenges and learning opportunities experienced during three KIVI-award-winning interdisciplinary medical projects are described in this paper. Also addressed in this paper is how the stand-alone project successes of the past can be embedded in a continuous research- and learning-line throughout the curriculum.

To finish the curriculum, students spent the first half of the fourth year on a minor, an educational package to broaden the knowledge of the student. This minor can be in line with, or complimentary to the major. About 45% of the students choose to follow the Engineering Physics minor. Within this minor, the student has the possibility to choose for a 280-hours project, performed by two students. Students can also choose to use this half year to prepare for master level education by following a dedicated pre-master program.

During the last half year, all students will perform a second full-time internship within a company or institute. The student should prove to be able to start, perform and finish a project on the appropriate level thus proving to be an Engineering Physics bachelor.

Most of the Engineering Physics graduates easily find a job within the areas of Research & Development or Engineering & Manufacturing. Various large high-tech companies and research institutes are headquartered in Eindhoven, for example IMEC, DIFFER, and ASML. At these companies and institutes, many of our students find an internship and many of our graduates can start their career. About 30% of our graduates choose to continue studying by following a master program, primarily at the nearby Eindhoven University of Technology.

4 Technical content of the interdisciplinary medical projects

The third-year interdisciplinary project can come from many different disciplines within the vast area of engineering, for example electronic sensors, acoustics, or 3D printing. In this paper, three medical projects are selected to illustrate what project teams from EEMM Engineering and Engineering Physics at Fontys can perform. All three projects used 3D printing as manufacturing process.

4.1 Heart model project

In January 2016, a cardiac specialist asked if it was possible to produce a 3D plastic heart model, based on Computed Tomography (CT) scan images of a heart of a healthy person. The purpose of this model was to validate various software packages, which can perform volume calculations on Magnetic Resonance Imaging (MRI) scan images.

CT scan images have a specific file format, called DICOM. To convert such a file to a STL file format that a 3D printer can use to produce a 3D model, was a serious technical challenge. It was an unknown conversion process for tutors and students, and it required many steps. One of these steps was to only incorporate the heart muscle and ignore all other tissues. Different human tissues absorb X-rays at different levels resulting in grey level differences in the calculated CT image. The right atrium and ventricle were combined into one cavity, the same was done for the left side. A third cavity was incorporated into the model, representing the actual heart muscle volume. The three volumes needed to be separately fillable with MRI contrast liquid and to avoid image artefacts the 3D print material should be MRI compatible.

The project team proved that the designed and 3D printed heart (see Figure 1) met the list of requirements. A follow-up project solved a slight leakage problem of the model by using a surface finishing process. The project result shows a glimpse of the future possibilities of 3D printing for creating realistic and cheaper medical models.

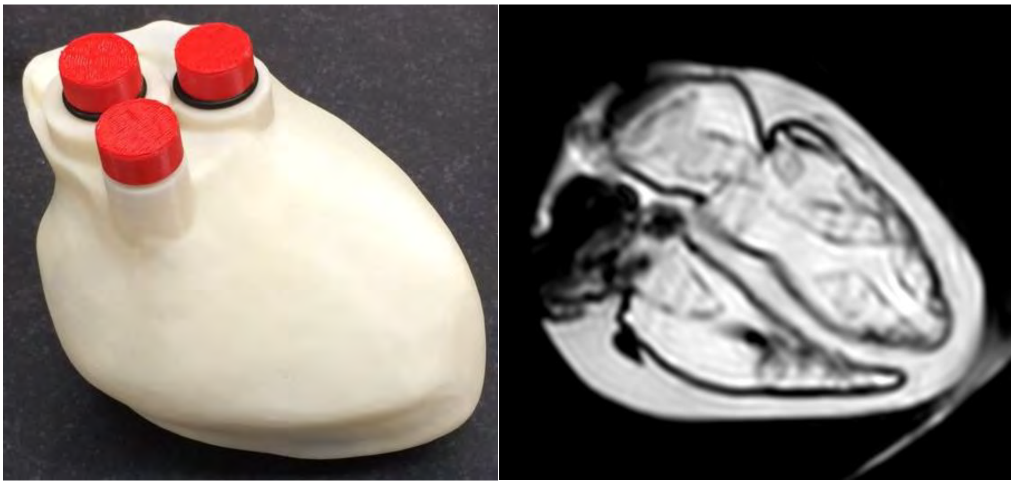

Figure 1. The 3D printed heart (left) and a MRI scan image of the model (right), largely filled with MRI contrast fluid.

This project was awarded with the KIVI-award of 2015-2016 because of the innovative nature of the project and in October 2016, an article was published in the digital journal "MBB'er in beeld" of the Dutch organization for radiology and radiotherapy technicians (Voorn, 2016).

4.2 Knee model project – first prototype

Learning complicated tests and treatments on actual patients is a time-consuming challenge for medical students. For several tests and treatments realistic learning models are available, for example resuscitation models of adults, children and babies. These models facilitate efficient and risk-free learning for the medical students. High-end resuscitation models can also give real-time feedback on the performance of the trainee, so that the student can practice without the need of a tutor being present.

Mid-2016, an orthopaedic surgeon commissioned the development of a learning model of a human leg, with feedback option. The purpose of the model was to train orthopaedic and physiotherapy students performing the Anterior and Posterior Drawer Tests of the knee.

The main technical challenge in this project was to produce a realistic knee model, which accurately represented the feeling of testing an actual human knee. The observed displacement of the knee during the Anterior and Posterior Drawer Tests varies from person to person. One of the influencing factors is the amount of injury of the cruciate ligaments. Four different categories are recognized according to the International Knee Documentation Committee (IKDC, 2000), varying between no observable displacement to more than ten millimetres. By using 3D printed and ready-to-use tubes of polyurethane with different stiffness, the four categories could be simulated. In January 2017, the first prototype of the learning model was realized, see Figure 2. In April 2017, the learning model was described in an article in the Dutch physiotherapy journal "FysioPraxis" (Voorn, Vrande, et al., 2017).

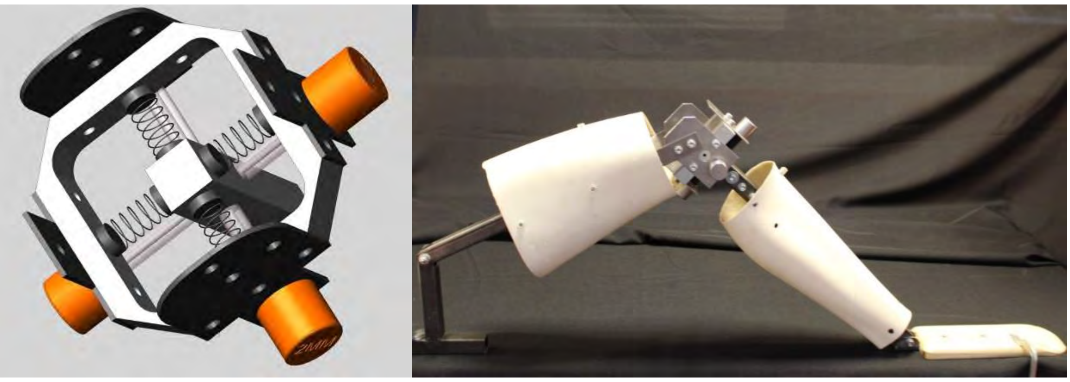

Figure 2. The mechanical design of the knee model (left) and the first prototype of the learning model (right).

4.3 Knee model project – improved prototype

A follow-up project team created an improved prototype of the model and incorporated a feedback system. Instead of polyurethane tubes, 3D printed modules were created containing metal springs to simulate the knee flexibility. Force and displacement sensors were built into the prototype and the measured values could be displayed on a prototype feedback system, see Figure 3.

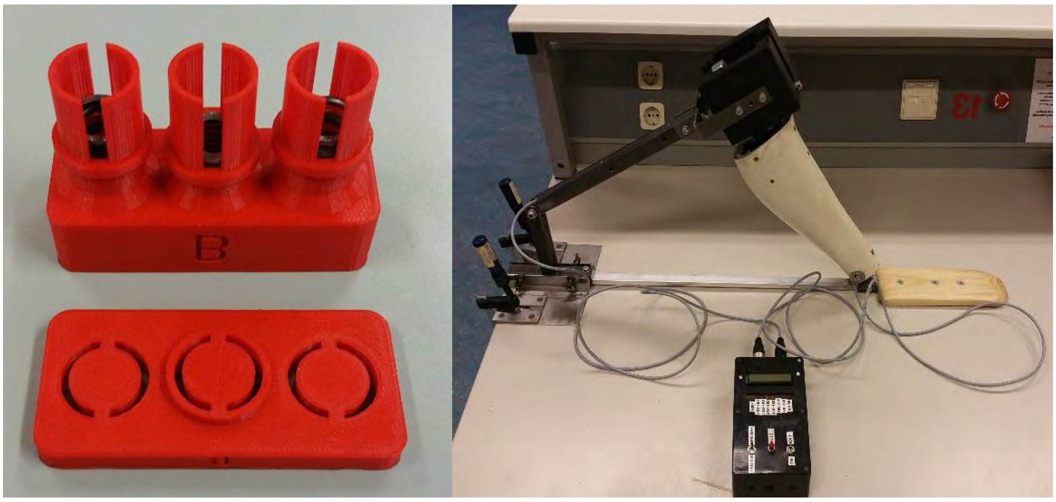

Figure 3. One of the 3D printed modules containing metal springs (left) and the second prototype of the learning model with feedback system (right).

The orthopaedic surgeon was very enthusiastic and posted the following on Twitter: *"Second prototype knee simulator for education cruciate ligament instability big success, nice collaboration with Fontys University."*

A group of physiotherapy students started a small-scale project to check if the second prototype could be utilized to teach the drawer tests to physiotherapy students. The conclusion was that there is an observable and clinically relevant improvement after training with the model.

Both knee projects were nominated for the KIVI-award of 2016-2017. The jury was unable to choose between the two projects and both were rewarded with the KIVI-award.

5 Challenges and learning opportunities

Performing real-life projects for medical doctors by groups of students from different engineering programs results in specific challenges for students and tutors. It also offers a variety of learning opportunities for the project team. In this section, the main challenges and learning opportunities are described.

5.1 Communication

Medical staff and engineers "speak a different language" and have their own specific culture and methods. This makes communication a challenge throughout the project for the project owner, the students and the tutor.

For example, a project owner with a medical background has no clear idea about the possibilities of doing projects with engineering students. On the other hand, the students need to broaden their medical vocabulary and explore the possibilities the university has to offer regarding technical and financial support. During the start of the project, it takes quite a while to define the exact project goals and boundaries. Especially EEMM Engineering students often find this start-up phase frustrating, as they prefer to start by designing and building a prototype. However, a well-known pitfall in engineering projects is to start without a well-understood list of requirements, or to start with requirements, which some involved parties do not fully approve of.

The students need to learn to present their plans and intermediate results in a way, which is understandable for the medical staff. Showing prototypes and design sketches in an early stage, rather than presenting them in a written or oral way, is much more effective. During regular interactive meetings, the project owner and the project team gradually shape the desired results. This way of working contains the main principles of the

Dynamic Systems Development Method, such as iterative development and collaboration (Agile Business Consortium, 2017). At the end of the project, the students realized that the major design decisions were made during meetings with the project owner, where early-stage design sketches and prototypes were discussed. However, planning regular meetings with medical doctors and tutors with busy agendas is not an easy task.

5.2 Different way of working

Although all the engineering students have experience with project work, there is a difference between the focus of the projects within EEMM Engineering and Engineering Physics. In EEMM Engineering projects, the design of a product plays a more central role; projects at Engineering Physics are mostly research projects.

EEMM Engineering students like to start as soon as possible with designing and building. The students are happy realizing their prototype designs in the workshop and are not comfortable with reading and brainstorming. Often, they have little experience with literature review and do not appreciate studying existing information. One of the skills many EEMM Engineering students learn and improve during interdisciplinary projects is systematically following the design process and explaining it to their project members. They experience the benefits of going step-by-step towards the final design in collaboration with the project owner. Looking back, the students realize that it all started with a sound list of requirements, based on studying earlier project results and relevant scientific articles.

In contrast, Engineering Physics students prefer to pose and answer research questions. For example by experimentally testing the performance of materials and products, compared to the performance as specified by the supplier. Often they have never been in a workshop and have little experience with early prototyping. They are more inclined to search for information and perform experiments. Effectively presenting the purpose, setup, results and conclusions of the performed experiments to their project members is one of the skills Engineering Physics students improve during interdisciplinary projects.

Working together, the EEMM Engineering and Engineering Physics students recognize the specific value of the various engineering disciplines and the benefit of working with other disciplines.

Two collaborating tutors, one from Mechanical Engineering and one from Engineering Physics accompanied the three projects as mentioned in section 4. This is not common practice for the interdisciplinary projects, but it proved to be very fruitful. On the one hand, students could discuss the specific technical issues with one of the tutors. On the other hand, the tutors could discuss the various views on the project challenges with each other and learn from each other's methods. Furthermore, it proved to be effective that one of tutors enjoyed creating new ideas (diverge) and the other tutor preferred to focus on the most promising ones (converge).

It was a major challenge for the project team to effectively recognize and combine the individual properties and skills of the various engineering students and the two tutors. However, this was one of the essential activities necessary to reach optimal project results and learning opportunities.

5.3 Collaboration within the project team

The well-known Tuckman's model describes the developmental sequence of small groups during a project: "forming, storming, norming and performing" (Tuckman, 1965). To reach the performing phase, the project team will have to go through the three preceding phases.

One of the techniques, which proved to be useful to reach and stay in the performing phase, was to do a 360-degree feedback session. Halfway through the project the students have exams, which temporarily reduces their available time for the project and gives them the opportunity to reflect and evaluate. During this period, a special review meeting was planned. The students were asked in advance to write down, for every student and for the tutors, one manner of behaviour, which makes that project member helpful in this project. In addition, one manner of behaviour was mentioned that could be improved to make the project more successful. This provided many useful insights for all project members and the possibility to adapt their behaviour already during the project. The tutors were surprised by the properly formulated feedback that the students came up with. Most of the feedback was easily accepted as it was based on the effects of observed behaviour during the project. Some students were not aware of the effects of their behaviour and used the opportunity to experiment with improved behaviour during the second half of the project. These improvements were greatly appreciated during the review meeting at the end of the project.

At the end of the second knee project all student were asked to write down one quality of the other students and one suggestion for improvement. The tutors studied the input by the students and discussed about the grades for every student. These grades and the argumentation were presented to the group during the final review meeting. The group discussed which grades were fair and which should be adapted. Some small adaptations (positive and negative) were made to come to group consensus on the final grades. Both tutors and students agreed that these final grades were representative for the individual contributions. Currently, the method of assessment of individual contributions of students during interdisciplinary projects is subject of discussion.

6 Improvements

Performing Project-Based Learning on a high level is not something learned in an instant by a team of tutors, but requires experience and continuous improvement. In this section, recently implemented and planned improvements are described.

6.1 Improvements implemented

Until recently, the methodology used in first-year projects was the seven-step approach of Problem-Based Learning, as described by Maastricht University (Maastricht University, 2003). However with the type of projects done and this methodology used, students did not get enough hands-on experience with project management skills, like planning the work that needs to be done and chairing efficient progress meetings. Starting this academic year, the methodology that students use from the beginning of their first project, is the eight-step approach of doing a research project as described by (Grit & Julsing, 2017) and the project management approach as described by (Grit, 2015). By using these approaches, the tutors will pay more attention to research and project management skills, instead of focusing on the technical content. Secondly, by working according to this methodology, tutors expect second-year students to be better prepared to shape and plan their ten weeks projects. With some adaptations, the mentioned eight-step approach for doing a research project can also be used for design projects.

Acquiring interdisciplinary projects requires specific skills and sufficient available hours. It takes time to maintain contact with potential project owners and define suitable project proposals and internships. For this reason, the available time for acquisition was increased for tutors working on acquisition. This makes it easier to find time to meet with (potential) project owners in an agenda filled with scheduled classes.

6.2 Improvement planned

A promising improvement is to acquire more projects within the spearheads of expertise. At Fontys, these spearheads are defined by the various Centres of Expertise (CoEs) and lectureships, for example the CoE High Tech Systems and Materials and the lectureship Applied Natural Sciences. Within this lectureship, the School of Natural Sciences has defined several Special Interest Groups (SIGs). These groups focus on a specific research topic and work hard to create, maintain and expand their network with companies and research institutes within that field. The knowledge and experience gained by the SIGs is used to improve and update the PBL curricula.

Currently, some projects acquired are one-time projects that do not fully utilize the knowledge and experience available within the university and its network. Within the newly created SIG of Engineering Physics, a well-defined research program is being set up during this academic year, which will create an ongoing flow of logically sequential projects. Based on the objectives that will be stated in this research program, the tutors will be able to perform research in order to systematically evaluate the performed projects and internships. In this way, a more step-by-step and research-based improvement of the Engineering Physics PBL curriculum is facilitated.

7 Conclusions

To reach bachelor level in Engineering Physics at Fontys University of Applied Sciences, the student will follow a Project-Based Learning curriculum. Starting with predefined small projects, after four years the student will reach the level of a starting professional by performing an interdisciplinary project and two half-year external internships.

Three award-winning interdisciplinary projects in the medical field have been described which illustrate the vast possibilities of 3D printing. One of the major challenges experienced during these projects, is that medical staff and engineers "speak a different language". Along the project, students will learn to clearly present their progress and medical staff will experience the possibilities of doing projects with engineering students.

While working in interdisciplinary projects, engineering students will learn from the specific qualities of different engineering disciplines. Students from Electrical & Electronic, Mechanical and Mechatronics Engineering use their experience in product design and like building prototypes in the workshop. In contrast, students from Engineering Physics are trained to define and answer appropriate research questions.

To improve the collaboration within the team, halfway through the project explicit attention was paid to giving and receiving feedback on behaviour shown by students and tutors. At the end of the project the students were asked for input for the assessment. The initial assessment by the tutors was discussed within the entire project team. Both activities created useful learning opportunities for both students and tutors.

The Project-Based Learning curriculum requires continuous improvement. Recently the first-year program was changed so that more attention is paid to project management skills, which will serve as an improved preparation for larger scale projects. A second improvement is to define the spearheads of expertise and set up a research program. By acquiring projects which are in line with this program a more step-by-step and research-based learning process is stimulated.

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Assessment in innovative engineering courses: A performance comparison between project based learning and team based learning

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Abstract

Innovative methodologies in engineering education are the new tendency that is being adopted by many universities worldwide. The conception that takes account that the students are de center of the knowledge is became a mandatory guide for the engineering courses. One of innovation methodology is project based learning (PBL) in which the students learn the technical concepts through multidisciplinary project when they are conceiving, designing, implementing and operating one prototype. In the other side there is another methodology which estimулates the students to develop transversal skills through the team work conception called team based learning (TBL).In this paper a comparison between both methodologies is presented considering the assessment outcomes .The scenario was the fifth semester of the Industrial Engineering course in a private university. After conducting statistical analysis the results presented the similar outocomes for both metodologies and some guides for improvements in this research are presented.

Keywords: Project Based Learning; Team Based Learning; Engineering Education; Assessment; Innovative Learning.

1 Introduction

Today many descriptions are considered for team learning as collaborative learning, cooperative learning and team-based learning as being integral part of high level engineering education. The universities are including in their curriculum the development of team work capabilities but they ask teachers to provide individual marks/grades. Learning in teams is very important but they conduct to some problems (Hansen, 2006) .The importance of the assessment for the team learning was described by Leijk, Wyvill, & Farrow (1996) and Li (2015) .When the team working is submitted to assessment consideration a range of implications take place, because a team mark is in the most of cases not a fair reflection of an individual's work (Conway, 1993) .The act in converting an individual's collaboration to teamwork into a numeric grade is a difficult activity (Johnston & Miles, 2004). It is important that the students feel confident that they will be recognized fairly from their contributions, and it is important to develop a proper functioning learning team that give high qualified outcomes.

In accordance to Lima, Silva, Janssen, Monteiro, & Souza (2012), the Project - Based Learning (PBL) has been one the main focus of discussion about active learning, as well as the way to select the curriculum alternatives for innovative methodologies in engineering education. PBL is one strategy for the teaching and learning in XXI century, which demands more commitment of the students and the professors. It demands that the professor takes in his mind the changes in the new activities and became in a learning coach and no more a simple teacher, and the students keep the responsibility for their own learning.

In this paper both learning methodologies are presented and evaluated: Team based learning (TBL) and Project Based Learning (PBL) .The research took place in a class of the course of industrial engineering. The lecturer was regarded to manufacturing process and the class was divided in groups composed of maximum six students each one. The project was to develop the whole manufacturing process for one specific auto part. Firstly the TBL was applied with the groups in the project development, being that in a period of fiftheen days the professor conduct a check point meeting. As the outcomes of this stage a team assessment was conduct. In the second phase the PBL was adopted as the learning methodology and the final assessment was performed and the outcomes were measured again. An statiscal approach was used to compare the outcomes from the two learning methodologies considering the individual performance for each student. The results are presents and commented. Finally the conclusion for the research is presented with the recommendations for the further works.

2 The PBL and TBL in Engineering Education

The Industrial Engineering course aims to capacitate a professional with solid scientific expertise who is able to design, model, implement, operate, maintain and improve integrated production systems of goods and services, involving human, financial, and material resources, technology, information and energy. In addition, it is expected that this professional know also how to specify, predict and evaluate the results obtained from these systems benefitting both the society and the environment, using specialized knowledge of mathematics, physics, humanities and social sciences together with the principles and methods of analysis and engineering design.

In line with the objective of the course, the student profile of this course should be a generalist with solid scientific and professional training to enable this person to identify, formulate and present projects linked to the design, operation and management of work and systems production of goods and/or services, considering the human, economic, social and environmental aspects, ethics and humanistic vision in meeting the demands of society. In addition, these professionals must be creative and flexible, have a critical spirit, initiative, judgment and decision making, be able to lead and work in multidisciplinary teams, have skills in oral and written communication and know how to value continuing education.

In order to promote the understanding about the two learning methodologies some definitions and considerations are described as following.

2.1 Project - Based Learning (PBL)

Constructionism examines an individual learning, step-by-step, and confirms that humans learn more when they are building something that can be shared with others (Grant, 2002). The goal of Constructionism is to achieve learning that value the subject's mental construction, supported by his or her own buildings in the world.

Consequently, learning based in projects is related to the constructivism, where the know-how is not absolute, but built by the student through his knowledge and global perception, sizing the necessity of deeply understanding, amplifying and integrating the knowledge (Bolander, Fischer, & Hansen, 2011; Crawley, Malmqvist, Östlund, Brodeur, & Edstroem, 2014). Constructivism proposes that students actively participate in their own learning, through experimentation, group research, stimulation of doubt and development of reasoning, among other procedures

According to the CDIO, we can define Project - Based Learning (PBL) as an instructional method in which students learn a range of skills while, also, creating their own projects, which could be a solution to a real-world problem (CDIO, 2010).

PBL is an active teaching method which aims to engage students in acquiring knowledge and skills through a real-world and well planned activities.

One of the first definition for PBL was given by Adderley (1975). For the author, PBL:

> (1) involves the development of a project, often, though not necessarily, proposed by the students; (2) involves the initiative of the student (or group of students), and it requires a variety of educational activities; (3) usually results in a final product, such as a thesis, a report of a project or a computer program, among others; (4) involves projects, which in most cases are long and take a considerable period of time to be completed, and (5) leads teachers to engage in a consultant role, rather than an authoritative position, at all stages of a project (initiation, conduct and conclusion).

Thomas (2000) seeking to answer the question: "What must a project have in order to be considered an example of PBL?" presents five core criteria for a successful approach:

> (1) - Centralization: Projects are an integral part of the curriculum. They are not peripheral. They are part of the basic education strategy, since students will learn the core concepts of the discipline through them; (2) - Question triggering: Projects must be focused on questions or problems that lead students to find (and even, to face) the central foundations of a given discipline; (3) - Construction Technique: The core project activities should involve the transformation and construction of knowledge by students; (4) - Autonomy: The development project is the students responsibility, without the typical supervision of traditional teaching and (5) - Realism: Projects should be realistic, dealing with concrete, tangible problems. It should not be a mere academic activity. They should have characteristics that allow the student the feeling of authenticity.

According to Powell and Weenk (2003), PBL involves students working in teams in order to develop projects by using the theory in practice. Furthermore, they must also learn to relate what they are learning to their future profession. Moreover, for them, PBL should place the student as the main actor of the teaching-learning process and relate content from various disciplines on a project.

Helle, Tynjala, & Olkinoura (2006) sought to define and distinguish PBL pedagogical or psychological reasons in this kind of pedagogical approach. For them, the most important feature of PBL is the fact of having direct oriented to real project, which serve to conduct learning activities. Furthermore, they have proposed a number of additional reasons in order to justify the use of PBL:

> 1) the construction of a concrete artifact forces the student (or group of students) to develop a series of learning activities during the stages of the construction process; 2) the control of the student in the learning process, since it is the student's role to make decisions about the pace of work and its sequence; 3) the contextualization of learning is evident in projects carried out by students; 4) the potential for the use and creation of various forms of representation, since as in professional life most activities require the use of interdisciplinary knowledge and 5) the existence of motivating features for students

For Duch, Groh, & Allen (2001), PBL should lead students in search of develop project, as well as the acquisition of skills, such as problem-solving ability, oral communication, written communication and teamwork, among others.

The labor market is demanding extraordinary professional skills and just knowledge is not enough. Thus, teaching through PBL provides many benefits for students, and improves their academic development. These authors emphasize, among others, the following benefits for students: they do not only gain knowledge, but they learn to do a project; they practice their skills and acquire others; they know how to behave in a group; they gain as practical activity, as it approaches those of their profession. In addition, the authors propose that: projects, whenever possible, should involve the university and the communities in surroundings; should evaluate students based on the reality that they will find in the labor market; should increase communication and unity within the classrooms.

The PBL has been proved to be one of the effective student-centred strategies in engineering education in many fields (Gavin, 2011; Neto, Lima, Mesquita, Ciciliano, & Losovoi, 2016). However, this concept has more application in vocational education schools than in engineering universities in China.

Recently, several Conceiving–Designing–Implementing–Operating (CDIO) Initiative collaborators in China have adopted their curricular planning to provide students with various levels of projects in the context of CDIO real-world systems and products (Crawley, Malmqvist, Östlund, Brodeur, & Edstroem, 2014). For the non-CDIO members, the PBL practices are not systematic and only applied in some individual courses.

2.2 Team - Based Learning (TBL)

The corporative world demands for engineers with abilities in teamwork skills as well as in the teamwork processes. The enterprises evaluate the capacity in teamwork by the engineers (Lewis, Aldrige, & Swamidass, 1988; Nengsheng, Xiaohua, & Yueyun, 2016). In the universities the team working is one methodology which stimulates the students learning in a collaborative way in order to reach results. Team working is adopted in the schools in order to develop in the students the abilities how solve engineering problems (Borrego, Kerlin, Mcnair, & Beddoes, 2013). Team working supports the development of transversal skills (Conway, 1993).

In the last twenty years the psychologists have developed conceptual foundations, stages, model and different approachs of team learning. Many theories were developed to explain the team learning as: motivational theories, social cohesion theories, cognitive theories and dynamic system.

The preparation of the academic staff in terms of team working is not rigorous in terms of training programs regarding learning and teaching teamwork (Palmer & Hall, 2011). Usually the educational psychologists theoretical literature are followed. More than the theoretical aspects of team learning it is very important to define that this subject is heterogeneous, occasionally cofusing and difficult to comprehend and implement in an engineering problem (Zhou, 2012; Tio, 2016).

The methodology of Team Based Learning (TBL) can be defined as learning method which presents solutions to real problems based on the synergy of the actions of the students joined in teams (Powell, 2004).In this work, a TBL approach was applied to empower the students to present a real project solution.

Team learning subjects, training manuals, guidelines and tools have been developed by academic institution, for example, Harvard University (HARVARD, 2015) and CDIO (CDIO, 2010; Taru & Juha, 2016) which are based on theoretical foundations considering points as how important is teamwork and how it is aligned with the constructivist theory education.

As a result, engineering academic staff do not prefer to include teamwork in their subjects. Even if they are asked by engineering schools and program directors to incorporate team learning in their subjects, they usually take the lowest obstacle path by simply asking students to complete a learning task or assessment item in teams (Nepal, 2012). They may also include teamwork if they believe it reduces the marking workload, especially in large student cohorts. Both these practices do not help to develop adequate teamwork knowledge, skills, products and experience and hence the core teamwork-based learning outcomes (Gogfrey, Crick, & Huang, 2014).

Simply asking students to complete a task or assessment item in teams is not the same as developing team work knowledge, teamwork skills, team work products and good experience. The team based assessment items without addressing core team work-based learning outcomes is recognized as a significant problem (Lebeau, Trevisan, McCormack, Beyerlein, Davis, Leiffer, & Thompson, 2014). Research demonstrates that placing students into teams without preparation, scaffolding and facilitation does not result in higher academic achievement nor the achievement of learning outcomes related to skill development and attainment, and can result in unclear goals, mismanagement, conflict and inequalities (Maturana, Gonzalo, Serrandour, & Luco, 2014).

There is an acknowledgement that teamwork has long suffered as a result of inadequate epistemology, and that principles of 'good practice' need to be identified and adhered if effective team learning outcomes are to be realized (Parr, Michael, & Towsend, 2002; Brewer & Mendelson, 2003).

3 Method

3.1 Context

In the fifth semester of the Industrial Engineering. The discipline was manufacturing processes. The students have never had classes under innovative learning methodology before. The course was conducted at night and 76% of the total of students worked during the day. The classes had four hour duration and occurred once a week.

3.2 Participants

The class was composed of 145 students, divided in groups with maximum six people. The class was compound by students with different ages, and economic class. Some of them worked in industry and the others in the commerce.

3.3 Design

During one semester the same class was submitted to two learning methodologies TBL and PBL. The outcomes were statistically analyzed. The class was divided in groups with maximum six students. Each group should develop the whole manufacturing process for one specific auto part.

3.4 Instruments

For the TBL evaluation one team assessment was conducted using descriptive conception, for each group there were six different exams, and the students could help themselves. The results of TBL evaluation were the individual grades obtained by the students. The PBL was evaluated through a project, wich followed a project management schedule using management tools. A full paper presentation in the end of PBL was mandatory, and the students should follow the state of art journals regarded to the PBL subject .

3.5 Procedure

In order to evaluate the TBL outcomes one team assessment was conducted where the group, with six people maximum, was evaluated being different exam content for individual student. For the TBL evaluation the content of the examination was the theoretical concepts regarded to different manufacturing processes common used in the auto parts enterprise. In the PBL case, each group should present a project of the manufacturing processes for one entire automobile component and a scientific paper about the project. In the PBL outcomes evaluation the final grade for each student was the grade of the group, nd this grade was compounded by: 50%regarded to the scientific paper,30%regarded to the final project presentation and 20% regarded to a grade obtained by one member of the group which was drawn for an individual test on the project content.

3.6 Data Analysis

The data obtained from the two evaluations regarded to the two methodologies were collected after the examination and analyzed students by student. Then the data were treated with descriptive statistical analysis. The data collection was performed during one semester of the manufacturing process discipline.

4 Results and Discussions

During the four months of classes and working in the project, two evaluations were performed to the different learning methodologies (PBL and TBL) considering a sample of 145 students.

A preliminary statistical analysis for each data sample could be seen in Figures 1 and 2. In the both Figures the frequency is plotted against the individual grade. The Anderson – Darling Normality Test results are presented as well as values for the Confidence Intervals.

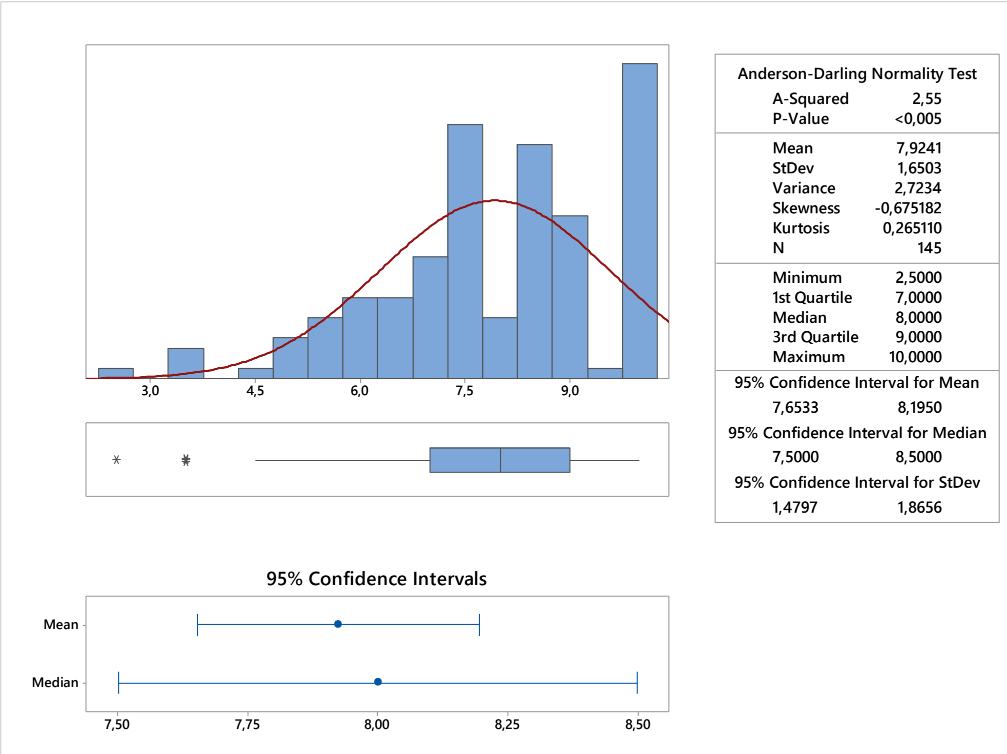

Figure 1. Preliminary statistical analysis for PBL evaluation.

The Figure 1 shows the results of the outcomes for each group of students using the PBL. Considering that the minimum grade to get the approval in the course is 6.0, there was some students that did not reach this grade, although the 95% of the Confidence Interval was located between 7.6533 and 8.1950.

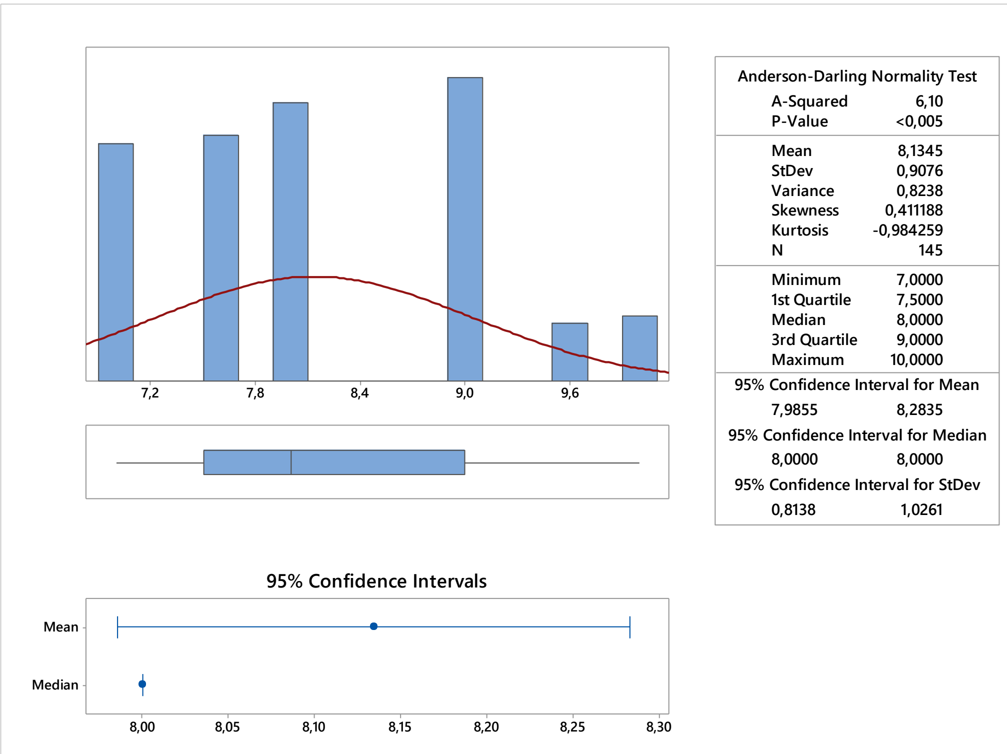

Figure 2. Preliminary statistical analysis for TBL.

The Figure 2 presents the results of the outcomes for each student when the TBL was applied. It can be observed that there was not student with the grade below the minimum 6.0 to get the approval in the course, no matter the 95% Confidence Interval for Mean is almost the same that obtained for the PBL.

As can be observed in the Figures 1 and 2,the data do not follow one Gaussian distribuiton, fact that can be justified by the mean of the system of grade atribuiton which could not allow one significative variation that force a non continous distribution of the data. It is importante reinforce also that the difference of varibility between the two assessment methodologies can be justified by the fact that the PBL gives the same grade to one group of students generating a significative impact on the the data variability.

A paired T-student test was performed to compare the individual performance for each student under the two kinds of assessment applied, the results are in the Table 1.

Table 1. T-test paired for two samples.

	Mean	Standard Deviation	Pure Error	Confidencel Interval (α=0,05)	P-value
P1	7,92	1,65	0,14	------	------
P2	8,13	0,91	0,08	------	------
Bias (P1 – P2)	-0,21	1,74	0,15	- 0,50 ; 0,08	0,148

It can be observed in the Table 1 the paired T – student test shows that for one the same significance level of 5% there are not statistical evidences that allow to claim that there is difference between the performance of the students for the two applied methodologies for assessment. This result can be considered one evidence that the methodology applied has one small impact n the students performance that other factors as the professor performance, students commitment, time of the dedication of the students, etc. As a consequence its is very important to increase the range of the studies with: other students from different universities, other courses and different disciplines in order to conclude that the degree of confidence level more higher over the influence of the applied method.

In accordance to the Figure 3, it can be observed that there is difference between the avarage value, and in the case of the statistical analysis be ignored, this difference could be used to distinguish one method from the other. But the statistical analysis shall always be considered for the data variation, as well as there are not evidence data of the difference in the students performance under the two methodologies.

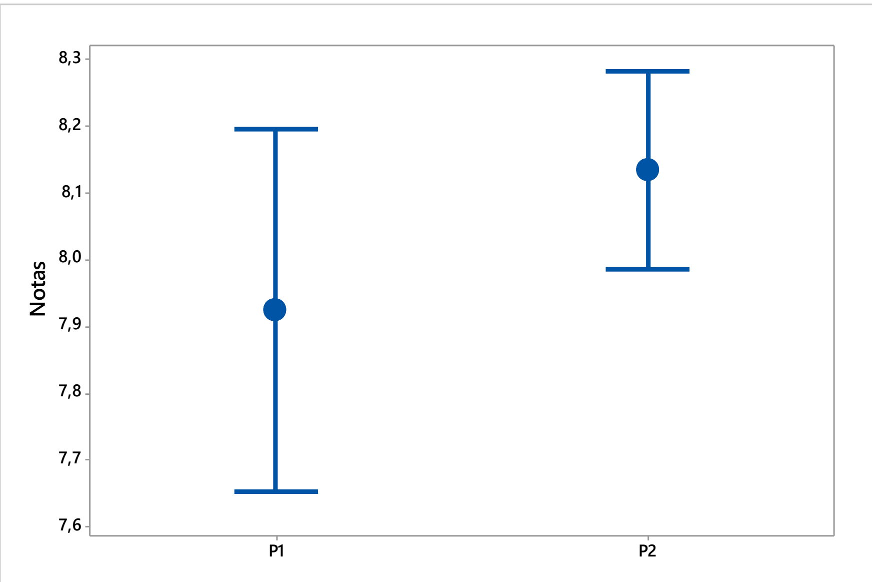

Figure 3. Confidence range (α=0,05) for the average grade.

It is mandatory that this study go ahead collecting more data and present more robust conclusions, including the identification with more precision the influences of the other factors already mentioned in this paper which can have one impact equal or bigger than the innovative learning methodologies applied.

5 Conclusion

During the deployment of this work the researchers had observed that PBL and TBL, as innovative engineering learning, improve the performance of the students in terms of the learning absortion. It observed that the commitment by the students was higher than the traditional learning methodology.

In the population of the students where the research was performed the impact caused by the application of active learning methodology is equivalent for the PBL as to the TBL.

More data are necessary to become the research more robust but the main conclusion is that the student is the main agent of the knowledge acquiring and it does not depend on the time of student dedication at the faculty, since the majority of them work in different enterprises during the day.

It is very important to increase the range of the studies with: other students from different universities, other courses and different disciplines in order to conclude that the degree of confidence level more higher over the influence of the applied method

One important point of this research is regarded to the statistical analysis which had been applied to evaluate the variation of the final results between the two learning methodologies. It had permitted one more accurate evaluation of the results and support the conclusion of this work.

Another improvement in this research in order to get high precision is to investigate the influences of the other factors already mentioned in this paper which can have one impact equal or bigger than the innovative learning methodologies applied. For example, one point that should be evaluate is the ability of the professor in working with the innovative methodologies as PBL and TBL. The other aspect that should be evaluate is how the discipline and its content could have an influence in the results.

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Advantages of Industry-Academia Partnerships for the Development of Professional Competences in Civil Engineering

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Abstract

The Civil Engineering undergraduate program offered by the Department of Civil Engineering of TED University – Turkey, in realization of the necessity to enhance both technical and transversal competencies of its students, requires successful completion of two one-month industry internships during summer semesters of the second and third years of the program. After completion of these internships, students are expected to enroll a summer practice course during subsequent fall semesters. Within the scope of these summer practice courses, students present and defend their work as a written report and an oral presentation. During the academic year of 2015-2016, two junior students of the program completed their internships at separate civil engineering companies in Austria and Greece by making use of the European Region Action Scheme for the Mobility of University Students (ERASMUS+) program. During their internships, these students were expected to get involved with technical activities such as production, design and research under the supervision of company engineers. This paper discusses the observed advantages and disadvantages of this project-based learning approach (or industry-academia partnership) through experiences and completed works of these students. The civil engineering companies at which summer internships were completed, were asked to rate the competences of the students through a questionnaire. Students' written reports and oral presentations were graded by the department faculty members by following a detailed predefined rubric. At the end of the process, students were asked to rate their experiences by completing a student evaluation questionnaire. In the present study, we utilized the document analysis methodology for data collection. More specifically the submitted written reports, company and student evaluation questionnaires, faculty grading reports were subjected to a content analysis. The two students of this Civil Engineering undergraduate program also acquired the chance to reflect their views directly by co-authoring this paper. The developed competencies of other 30 undergraduate students of the program that completed their internships within Turkey are also discussed in a comparative manner.

Keywords: Project-based learning, Academy-industry partnership, Civil Engineering Education, Professional Competences, ERASMUS+ program.

1 Introduction

Civil Engineering professionals often work on interdisciplinary problems by mobilizing resources (i.e. knowledge, abilities and values) from a wide range of areas extending from application of mathematics and science knowledge to design and implementation of original, innovative and suitable civil engineering systems to teamwork and professionalism. These resources can be viewed as required competences of professionals of this field (Le Boterf, 1997). These competences can be technical (i.e. specific to the field of engineering) or transversal (i.e. transferable between different professional fields) (Lima et al, 2017[a]). In the above given example ability to apply knowledge of mathematics and science to design and implementation of original, innovative and suitable civil engineering systems is a technical competence whereas ability to work as part of a team or ability to act in a professional manner is a transversal competence. The need for developing both technical and transversal competences within the scope of undergraduate engineering education has been recently emphasized by several engineering professional associations (i.e. European Society for Engineering Education, United States National Engineering Education Research Colloquies) and accreditation organizations (i.e. Accreditation Board for Engineering and Technology, European Network for Accreditation of Engineering Education) (Lima et al 2017[b], Christie and Graaff, 2017). Project-based learning (PBL) is a pedagogical model with which this objective can be achieved. More specifically, PBL can be applied to development of undergraduate engineering curriculum that would provide students with academia-industry interaction opportunities and enable them to develop both technical and transversal competencies in real professional environments. The pedagogical model of PBL had been available for more than fifty years (Christie and Graaff, 2017) however its strengths were realized more over the last decade.

Project-based learning refers to the theory and practice of utilizing real world work assignments on time limited projects to achieve clearly stated performance objectives and to facilitate individual and collective learning (Smith and Dodds, 1997). Strengths of project-based learning as a pedagogical model have been underlined in works of several authors'. Revans (1971), Argyris and Schon (1974, 1978) emphasize that in project-based learning, participants engage in major **self-reflection** on their learning assumptions or theories in use through participating in solution of real-life problems. This prevents learning experience from turning into an unreflective self-repeating pattern (superficial learning). Cunningham (1993) suggests that project-based learning ensures deep learning by bridging the gap between researchers and practitioners and this is achieved by combining theory building with **research** on practical problems. Wenger (1998), Brown and Duguid (1991)'s work emphasizes the importance of the **team-work dimension** of project-based learning. They argue that learning occurs naturally through participation in the practices of social communities and through participator's construction of identities in relation to these communities.

In the 1980s and 1990s, education researchers increasingly realized that when students are bored and unengaged, they are less likely to learn (Blumenfeld et al., 1991). Studies of student experience found that almost all students are bored during lectures, even the ones who score well on exams (Csikszentmihalyi, et al., 1993). By about 1990, it became obvious to education researchers that the problem was not the fault of the students; there was something wrong with the structure of lectures. Studies indicated not only the engagement problem during lectures but also resulting superficial learning (Gardner, 1991). Several decades before, education researchers resorting to cognitive sciences tried to uncover the cognitive structure of deeper conceptual understanding. These efforts brought to foreground the pedagogical model of project-based learning that was first applied at Aalborg University in 1970s. Project-based learning is based on the constructivist findings that students gain a deeper understanding of the material when they actively construct their understanding by working on real, meaningful tasks and problems that emulate what experts do in real-world situations. Further, the most effective learning had been shown to occur when the learning is situated in an authentic, real-world context.

Prof. Dr. Öktem Vardar, founding rector of TED University and a reviewer of the European University Association (EUA) Institutional Evaluation Program, was closely following these advancements in the area of education science and ensured that such innovative teaching methods are followed at TED University by making them part of the university mission (''TED University Mission'', 2017). At TED University, even the classrooms were designed such that project-based learning type pedagogical models can easily be utilized (Figure 1). Similar interior design applications involving circular tables, small classroom spaces, wide-screen wall mounted monitors can also be found in other institutions advocating active learning or more specifically project-based learning such as Aalborg University and Nanyang Technological University. In addition to TED University, Koc University and Sabancı University are the other main institutions in Turkey that exercise innovative teaching methods.

Figure 8. Project-based learning friendly interior design examples.

Despite these affirmative efforts, the nationwide undergraduate engineering education in Turkey still needs to be enhanced in several aspects. Based on the information provided by the Turkish Higher Education Council

(2017), the total number of students currently enrolled to an undergraduate civil engineering program in Turkey is 60,995. According to Özcebe (2014), the total number of undergraduate civil engineering programs in Turkey increased by 115% between 2009-2013 reaching 105 and the total number of students being accepted to an undergraduate civil engineering program every year increased by 95% over the same period reaching 10,861 (Özcebe, 2014). It is partly because of this drastic increase both in the number of students enrolled to an undergraduate civil engineering program and departments providing undergraduate civil engineering education over the limited time period of four years that a recent survey conducted nationwide by the Chamber of Civil Engineering indicates that only 31% of the undergraduate students rated the education they are receiving as 'good' or 'very good'. 80% of the students indicated that they are not receiving adequate number of projects and experimental assignments during their undergraduate education hence they are not finding themselves well prepared to the construction sector in this respect (TMMOB İnşaat Mühendisleri Odası, 2018). On average these students indicated that apart from attending lectures every week, they are only separating 2.6hrs to complete assignments, prepare for exams; only 30% indicating that they are separating 4-6 hrs per week per course as foreseen by the Bologna process (Figure 2). This is another indication that students are not practicing the theoretical knowledge they are gathering on adequate number of application based tasks.

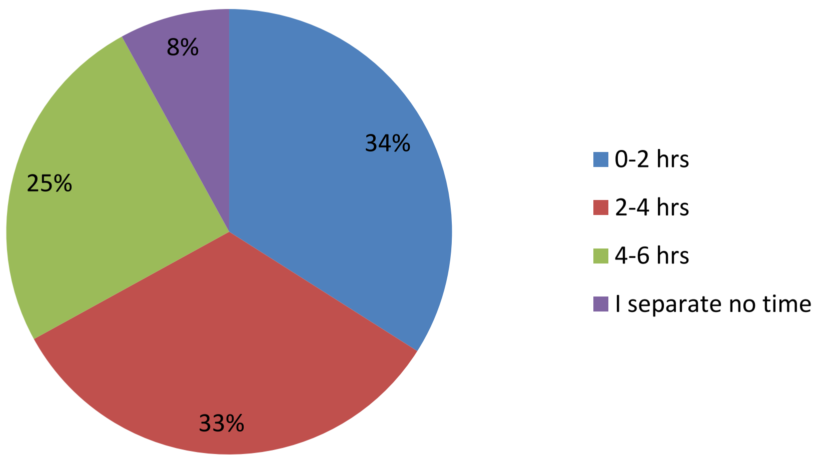
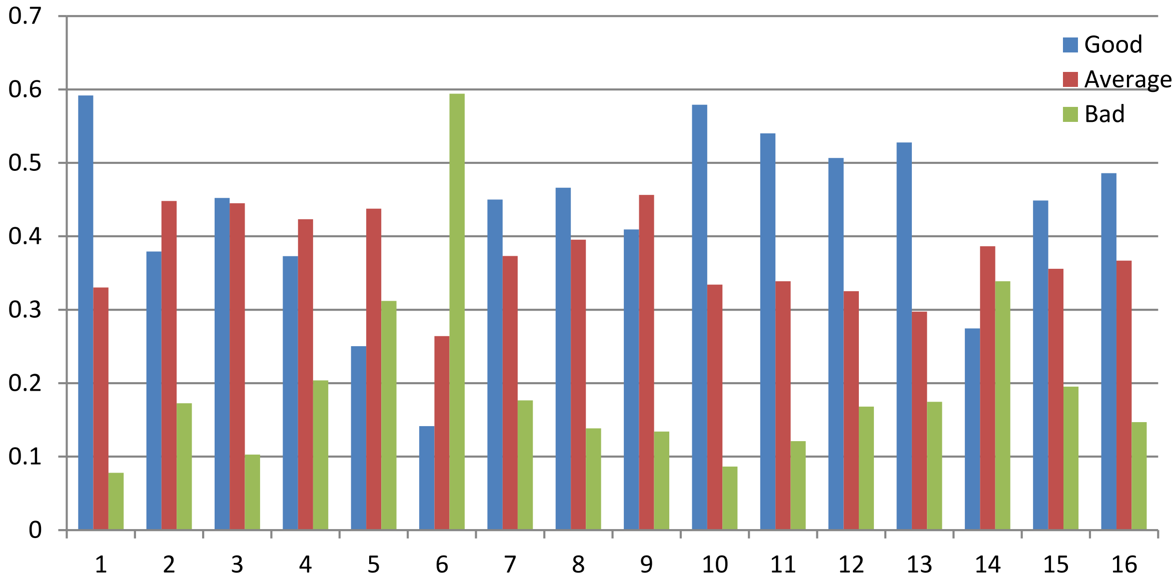


Figure 2. Number of hours undergraduate civil engineering students in Turkey separate for revising, completing assignments every week per course (TMMOB İnşaat Mühendisleri Odası, 2018).

When 16 different competencies are defined both technical and transversal and students are asked to rate the level at which they were able to develop these competencies during the civil engineering undergraduate education they are receiving, up to 35% of the students stated that they found themselves weak regarding transversal competencies, up to 60% of the students stated that they found themselves weak in communicating on technical issues in English both verbally and in writing and up to 30% of the students stated that they perceived themselves weak in utilizing modern engineering techniques and tools (Figure 3). Although 90% of the students stated that they only or most of the time use the library as an appropriate space for studying, only 30% of the students found themselves weak in researching and only 10% found themselves weak regarding life-long learning awareness. It should be underlined that only 1668 students (less than 3% of the total undergraduate civil engineering students) answered the above mentioned survey. Results are nevertheless valuable as they correspond to the only available countrywide data on students' perceptions and study habits.

Despite this rather grim countrywide general picture, the civil engineering undergraduate program offered by the Department of Civil Engineering of TED University – Turkey, in realization of the necessity to enhance both technical and transversal competencies of its students, requires successful completion of two one-month industry internships during summer semesters of the second and third years of the program. Through these summer practice courses, the project-based learning pedagogical model is exercised. This paper discusses the observed advantages and disadvantages of this tested project-based learning approach or industry-academia partnership through experiences and completed works of undergraduate civil engineering students at TED University.



1.Ability to apply mathematical knowledge to civil engineering problems
2.Ability to design experiments; collect , analyze and interpret experimental data
3.Ability to think analytically and to use knowledge effectively
4. Research consciousness
5.IT with modern engineering techniques and tools
6.Ability to communicate effectively in writing and verbally in a foreign language on technical topics
7.Ability to work effectively as part of a team
8.Ability to communicate verbally in Turkish
9.Ability to communicate in writing in Turkish
10.Ability to perform effective self-learning
11.Lifelong learning consciousness
12.Sensitivity towards social problems and participation awareness towards their solution
13.Awareness towards protecting the environment
14.Contribution of nontechnical elective courses towards personality development
15.Contribution of social activities to personality development
16.Development of ethical understanding

Figure 3. Perceived developed competency levels of Turkish undergraduate civil engineering students in 16 separate areas (TMMOB İnşaat Mühendisleri Odası, 2018).

2 Project-Based Learning through Summer Practice Courses

2.1 Summer Practice Courses at TED University

As mentioned above as well, the Civil Engineering undergraduate program offered by the Department of Civil Engineering of TED University – Turkey requires successful completion of two one-month industry internships during summer semesters of the second and third years of the program. After completion of these internships, students are expected to enroll to a summer practice course during subsequent fall semesters (CE399 Summer Practice I and CE499 Summer Practice II). Within the scope of these summer practice courses, students present and defend their work as a written report and an oral presentation. These summer practice courses are expected to contribute to the following program learning outcomes:

- Program Learning Outcome 3: Act professionally and ethically
- Program Learning Outcome 4: Appreciate cultural diversity, respect individual and cultural differences
- Program Learning Outcome 6: Identify, formulate, and solve engineering problems
- Program Learning Outcome 7: Demonstrate effective oral and written professional skills in English
- Program Learning Outcome 8: Practice good working habits, time management, and self-discipline

Table 1. Course learning outcomes- program learning outcomes connectivity matrix.

	Program Learning Outcomes				
Course Learning Outcomes	**PLO3**	**PLO4**	**PLO6**	**PLO7**	**PLO8**
Prepare a technical report in English				x	
Report the technical work completed in English orally to an audience of colleagues and faculty members				x	
Demonstrate good communication skills at the construction site/design office		x			x
Demonstrate understanding of ethical behaviour with respect to engineering practice	x				
Demonstrate good time management and professionalism skills					x
Recognize societal impacts of the engineering works		x			
Identify real life engineering problems			x		
Apply problem solving skills to real life engineering problems			x		

The summer practice courses' learning outcomes-program learning outcomes connectivity matrix is provided in table 1. The full list of program learning outcomes for the civil engineering undergraduate program under consideration can be accessed from the main departmental web site (''TED University Civil'', 2017) as well as program learning outcomes-offered undergraduate courses connectivity matrix. According to this connectivity matrix 'Program Learning Outcome 3: Act professionally and ethically' is also supported by student development seminar, construction management, capstone design courses; 'Program Learning Outcome 4: Appreciate cultural diversity, respect individual and cultural differences' is also supported by common core, free, minor area elective courses and the student development seminar course; 'Program Learning Outcome 6: Identify, formulate, and solve engineering problems' is the learning outcome supported by the highest number of courses that represent a wide spectrum of courses; 'Program Learning Outcome 7: Demonstrate effective oral and written professional skills in English' is supported by departmental courses with experimental applications as well as common core, free and minor area electives and capstone design courses; 'Program Learning Outcome 8: Practice good working habits, time management, and self-discipline' is supported by capstone design and student development seminar course. Uniqueness of the summer practice courses is because of the fact that problems worked on within the scope of these courses are real life problems, problem solving is conducted at real life working environments, good working habits, time management and self discipline are exercised at real life working environments. Also the fact that reports written and oral presentations conducted are on technical topics make these experiences rare and important.

Based on the rubric prepared for the summer practice courses, the content (60% of the total grade), format and style of the written reports (20% of the total grade) and of the verbal presentations (10% of the total grade for the content of the verbal presentation and remaining 10% for the format and style of the verbal presentation) are considered separately. Students are expected to describe the activities performed during their summer practices (i.e. activities performed at the construction site for the CE399 summer practice I course and activities performed at the design office for the CE499 summer practice II course) in detail; explaining how the knowledge and skills learned at the university as oppose to knowledge and skills developed through self-learning were applied to real world problems during the internship experience. Students are especially expected to comment on any new tools or technologies they encountered during their summer practices and explain how these new tools or technologies were utilized as part of the tasks performed. Students are also expected to explain which work related ethical problems they became aware of during their internship experience and how these problems were handled or managed by the company hosting them. In addition to ethical problems, students are expected to observe and comment on the economic, environmental, and societal impacts of the engineering works completed by the company. Students are also expected to demonstrate good English Language usage skills both in their written reports and verbal presentations with grammar, spelling and punctuation errors minimized as the language of education is English at TED University.

2.2 The ErasmusIntern Project

Erasmus is one of the lifelong learning programs of the European Commission. The Erasmus program has been active since 1987, which provided study abroad experience to approximately three million students until now. From thirty four countries (European Union member countries as well as Macedonia, Iceland, Liechtenstein, Norway, Switzerland and Turkey) approximately 4900 institutions are part of the Erasmus program that is considered to be the most successful study abroad program in the world. Turkey, as a candidate country for the European Union membership, joined the Erasmus program back in 2004 and until now a total of 22,516 Turkish students utilized this program and in return 6908 E.U. students visited Turkey (''Erasmus Facts'', 2017). ErasmusIntern is one of the projects of the Erasmus program through which individuals seeking international training opportunities find vacancies in companies and organizations. The main aim of this project is to improve accessibility and quality of international internships (''ErasmusIntern'', 2017). Two students of the undergraduate civil engineering program of TED University through the ErasmusIntern project of the Erasmus program completed their second summer practices in Gunskirchen, Austria and Chalkida, Greece back in 2016 and presented their experiences both verbally and as written reports by enrolling to the course CE499 in the fall semester of 2016-2017 academic year. The hosting company in Austria was Franz Oberndorfer GmbH which is a local but deeply rooted construction company specialized in design and mass production of precast concrete structural elements. During the summer period of 2016, the company was aiming to open-up to the world market, especially provide precast concrete structural elements to construction companies in People's Republic of China. Hence, the company was interested in the seismic design of precast structural elements and updating their catalogue with a range of earthquake proof structural elements. For the hosting company, this was the main reason behind accepting an intern from Turkey, which is a seismically active country where earthquake resistant design is considerably emphasized. The hosting company in Greece on the other hand was Seismosoft that was established back in 2002 with the aim of providing powerful and state of the art analytical tools to the earthquake engineering community. Over the last decade and a half, the Seismosoft company developed and marketed a series of softwares such as SeismoStruct, SeismoSpect, SeismoSignal, SeismoMatch, SeismoArtif and SeismoBuild. During the summer period of 2016, the company was aiming to open-up to the market in Turkey and engineers of Seismosoft were in the process of incorporating TS500 (2000) and TEC(2007) into the SeismoStruct software. During this phase, by accepting an intern from Turkey, they ensured that verification of newly implemented codes was completed by a student familiar with the TS500(2000) and TEC(2007) documents. They also ensured that they received help regarding the Turkish language as they were in the process of translating the language of the user interface of the SeismoStruct software from English to Turkish, a critical issue for the company that would enable them more easily enter into the Turkish market.

2.3 Developed Competencies through the Summer Practice Courses

When students taking part in the ErasmusIntern program were asked to compare their experiences with their previous summer practice experiences that were completed in Turkey at two different Turkish hosting companies (both were considered to be leaders in the Turkish construction sector), they both underlined that expectation of the hosting companies were very different and as a result of the latter experience they gathered deeper knowledge and skills. In these students' words 'the Turkish hosting company only assigned minor tasks and trivial responsibilities. As an intern, we had no effect on the ongoing works of the company. The hosting company expected a total observer status from the interns and provided the tools and the environment for the best observation experience under a close master-apprentice relationship with the supervising engineer. From the company's perspective, the success of the internship and the level of the intern were assessed by how much the essence of the practical work done was grasped by the intern and how easily the intern adapted to the construction site environment. The majority of the assignments given were observing and reporting of the construction process, checking or recalculating the past works of the supervising engineers or going through manuals and technical drawings.' Students described their experiences through the ErasmusIntern program however as 'the hosting companies stand firm and force the intern to behave like one of the employees. We were perceived as assets. Instead of demanding mere observations or trivial exercises, the hosting companies expected concrete contributions to the ongoing work under the supervision of a senior engineer. After a quick assessment of interests and abilities of the intern, we were assigned to a department where we played a role in contributing to the goals and interest of the company. The assigned tasks were highly interesting and challenging.'

Another important dimension that was underlined by these students was the research dimension included in their summer practice experiences. At the Franz Oberndorfer GmbH company, the student was expected to research on the seismic design provisions in use in China, be familiar with state of the art research on seismic behavior of precast concrete elements and shear walls. Similarly at the Seismosoft company, the student was expected to research on seismic behavior of concrete members, similarities and differences between TEC(2007) and Eurocode 8 (CEN, 1998-1). These tasks gave the students the opportunities of practicing the knowledge they gathered in the introductory level reinforced concrete design course however were advanced tasks for their level that promoted deep learning and increased their motivation. As a result students were observed to gather considerable amount of knowledge on earthquake resistant design prior to actually taking a course on earthquake resistant design.

Students also mentioned that as not only Turkish institutions and companies were involved in their summer practice experiences, during their second internship periods they felt more responsible and obligated to represent the Turkish civil engineering students well. According to their statements involvement of international organizations such as the European Commission, international companies and assignment of real engineering tasks that have not been completed by others previously enforced professionalism, good working and self-discipline habits for these students. These students extended their summer practice experiences beyond the required period of 4 weeks. As a result, they were able to practice English language both in written and spoken form intensively over a prolonged period of time. Due to the fact that students were reporting back their progress in writing and in the form of oral presentations to their supervising engineers during their summer practice experiences, gave the students the chance to practice communicating the work completed several times before actually presenting their final works to the department. Students, hence, were observed to describe the work completed more effectively by applying the correct terminology, being able to provide extended descriptions while taking the subsequent summer practice course.

Both students mentioned that before starting their summer practices, they were concerned regarding how Austrian and Greek societies would perceive their presence as an intern due to rather deep rooted political, ethnic and religious problems between Greece and Turkey as well as Austria and Turkey. However, they also mentioned that these concerns soon proved to be unwarranted. As they spent more than 2 months in Greece and Austria as interns, they got the chance to observe closely how ordinary people behave in work environment and during their free times. Also these students mentioned that they identified many similarities between their own way of life and their hosts'. As a result of their internship experiences abroad, they also in their own words 'noticed importance of respecting individuals and cultural differences and using these diversities as a success busting drive in business life'. Students completing their internships in Turkey also mention that after completing their internships they can better appreciate cultural and individual diversities however this is believed to be more in the form of appreciation of social class differences as probably for the first time they are working closely with the construction workers.

When the trainee evaluation forms filled by Franz Oberndorfer GmbH and Seismosoft company officials were assessed, it was observed that both of the involved students were found to be highly successful. They were further found to be highly competent regarding program learning outcomes 3, 4, 6-8 (as listed above) that are the main targets of the CE399 and CE499 summer practice courses. Both companies mentioned openly that they would hire these students as employees in their companies in the future. The company officials mentioned that from their perspective working with the civil engineering students of TED University 'triggered new ways of approaches' in their works and 'forced them to go beyond their every day routine, to approach the tasks from different perspectives and with updated theoretical knowledge'. The company officials also mentioned that as 'the interns were not flooded and distracted with the daily works of the companies, they were able to progress in the assigned tasks quickly and provide feedback to involved employees through regular meetings.' In the case of Franz Oberndorfer GmbH company especially, with the research conducted by the intern on the seismic behavior of shear walls and precast concrete elements, they were able to update their theoretical knowledge in these areas in an efficient manner.

When these students' success rates regarding content, format and style of the written reports as well as those of verbal presentations (average grade received for content of the report: 90/100, average grade received for the format and style of the report: 88/100, average grade received for the content of the verbal presentation: 100/100, average grade received for the style of the verbal presentation: 90/100) were compared with those of all the students who enrolled to the CE399 and CE499 courses until now, it can be observed that they are well above the general average performance (average grade received for content of the report: 73/100, average grade received for the format and style of the report: 75/100, average grade received for the content of the verbal presentation: 70/100, average grade received for the style of the verbal presentation: 65/100). By the faculty members, the main problem was identified as the poor English Language usage skills demonstrated by the students. As an improvement measure, a short technical writing course was included within the CE399 and CE499 courses (first four weeks of the semester) during which students regularly meet with English Language School instructors of the TED University and discuss their written report and verbal presentation preparations. To the knowledge of TED University officials, this experience represents the first example of a technical writing course given to engineering students at undergraduate level. The analysis of the effects of this change has yet to be made as is very recent. Through the study conducted within the scope of this paper several other improvement measures that can be taken were identified (i.e. requiring completion of real engineering tasks rather than observational tasks, research dimension, self-learning dimension). However these mainly require training the officials of the hosting companies as well, which is a challenging task given the considerable number of hosting companies involved. However through stakeholder professional organizations such as the Chamber of Turkish Civil Engineers, this change can be ensured over a reasonable period of time. The academia-company collaboration through the summer internship courses also underlined some weaknesses of the curriculum being followed (i.e. department students should be exposed to more applications on program development throughout their undergraduate education. The summer practice experience of the student at the seismosoft company could have involved program development in addition to verification of the software).

2.4 Improvement Suggestions for the Erasmus Program

Although both of the students' views on the Erasmus program were quite positive, they nevertheless defined the involved bureaucracy as tedious and developed some suggestions towards improving the system. One student underlined the fact that all documents are required in hardcopy form and if this system is replaced by an equivalent electronic system, time spent can be minimized. The other student underlined the fact that she was in contact with the Erasmus coordinator at the sending institution (TED University in this case), supervisor at the hosting company, Bank officials, Turkish National Agency as well as TED University Civil Engineering Department Erasmus coordinator hence she had to communicate with several parties at the same time. She suggested changing the system such that students would have to be in contact with a limited number of these parties involved (i.e. Erasmus coordinator of the sending institution only).

3 Conclusions

This paper proves once again importance of programs such as the Erasmus program and resulting internationalization of the higher education. Through the ErasmusIntern project of the Erasmus program, it was possible to apply the project-based learning pedagogical model to summer practice courses successfully. Experiences of students who were part of this project clearly indicate importance of the **real-life task**, the **research**, the **practicing in a social community** dimensions of project-based learning in promoting deep learning.

The discussions held within the scope of this paper are limited to the state of undergraduate civil engineering programs in Turkey. However, one can safely state that similar trends are also prevailing for other undergraduate engineering programs in Turkey. Over the last decade, the number of institutions offering undergraduate civil engineering education as well as the number of students accepted to these programs more than doubled. Only available survey results are those of Chamber of Turkish Civil Engineers, which indicate that majority of these students are receiving undergraduate education under conditions characterized by deprived physical and personnel resources. Same survey results indicate that students are not applying theoretical knowledge gathered on adequate number of project works and experimental exercises (TMMOB İnşaat Mühendisleri Odası, 2018). This makes successful application examples of up-to-date, innovative pedagogical techniques, such as the one shared through this paper, even more crucial for countries facing similar educational problems as Turkey.

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University-Business Cooperation: Development of a Strategic School Unit at ESTG/IPVC

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Abstract

The goal of this paper is to discuss the practical challenges found in the operationalization of University-Business Cooperation (UBC) strategies, based on a contextualized example of a at Escola Superior de Technologia e Gestão (ESTG), the technologic school of Polytechnic Institut of Viana do Castelo (IPVC). The paper describes the process of development and implementation of a UBC unit, establishing broad range of partnerships with public, private and voluntary sector organisations, wich aims at fostering and strengthening the relationship between science and organisations. This Unit emerged from an organizational attempt to aggregate several Cooperation initiatives, including PBL Projects taking place within diverse courses, and enhance the possibility to create a strategic school "unit" in accordance with international recommendations in the field of UBC. The unit intends to consistently establish the conditions for cooperation between academia and organizations, providing guidance and strengthening efforts in the value chain between higher education and organizations. In general, the unit activities aim at maintaining high levels of strategic orientation, enhancing the development of student's skills., whilst contributing to social and economic development. It intends to encourage and promote knowledge sharing and transfer, create partnerships and long-term opportunities, developing and increasing students' creativity and innovation, through proven methods such as active teaching-learning methods, and therefore, increasing students' employability. These activities require the acquisition of knowledge associated with the development of an entrepreneurial stance, whilst supporting and promoting the diversification of sources of financing higher education. Simultaneously, this approach will provide a judicious and sustained development of the professional relationships and the work environment within and outside the school. In this School, different courses have established partnerships with several organisations since a long time, creating the necessary conditions for project-based learning approaches, and for the development of students' employability skills. However, these initiatives were carried out by teachers and courses, on a voluntary and independent basis. This paper presents the development process and organization of a UBC unit and describes the different hubs that are being proposed. Critical factors to take into consideration for the success and improvement of UBC initiatives will be discussed and pointed out, in the light of the existing literature in this field.

Keywords: University-Business Cooperation (UBC), Active Learning, Implementation, Polytechnic.

1 Introduction

Polytechnics in Portugal are public institutions spread along the country, mainly in rural locations where they act as the main higher education provider in the region, having an additional economical value by increasing competences and employment (Alves et al., 2015). Since 2006, Portugal has entered a democratization process of the higher education system, increasing the access to science (Heitor & Horta, 2014) and stimulating major competence development, by providing the opportunity for a large majority of students to access public institutions. Public polytechnics have a key role in rural areas, where students are often the first-generation students (FGS) in higher educational systems (Spiegler & Bednarek, 2013). Also, specifically for this first-generation student, institutions have a crucial role in supporting and developing motivation, by understanding their needs, and their social, familiar, or individual underlying processes, that may hinder students to remain in higher education systems (Petty, 2014). Stebleton and Soria (2013) have identified barriers that first-generation students are more likely to encounter that can influence their performance on higher education, compared to non-first-generation students, such as job responsibilities, family responsibilities, perceived weak English and math skills, inadequate study skills, and feelings of depression. These students often see themselves as "the ones that are going to be unemployed." Under these circumstances, as is the case of IPVC (Viana do Castelo

Polytechnic Institute) that serves mainly rural communities, it is highly recommended that higher education institutions (HEIs), find more capable learning methodologies that can enhance students' engagement and motivation. As Petty (2014) refers, in this motivation process, it is relevant that more active methodologies are used so that these differences can be overcome and that these students can achieve a higher education development. Most of these sound methodologies are of a collaborative nature, widely acknowledged in the literature as University-Business activities (UBC). UBC is the collaboration of universities (Polytechnics included) and businesses, often with the support of governmental organisations, for mutual and societal benefit, helping universities to face the problem of decreasing public funds, and helping businesses to gain and maintain their competitive advantage in today's dynamic international markets (Davey et al., 2011). UBC has become one of the top priorities for governments, higher education policies, education systems (Plewa, Galán-Muros & Davey, 2015) and has attracted a huge demand from employers. This demand from different stakeholders has enabled universities and businesses to work together in the creation of cooperation initiatives that can provide relevant results for both (Hasanefendic, Heitor & Horta, 2015). Hasanefendic et al. (2015) debated the relevance of the intermediary institutions, such as the public polytechnics that should promote problem-based practices, learning together with the implementation of short-term project-oriented research. These practices can be integrated in university-business cooperation and respond to several goals from different stakeholders. The practices are relevant in order to respond to the student's needs, as stated above, but can also provide relevant research contexts through this privileged access to organizations, including social and economic actors in the region, through formal or informal collaborative mechanisms (Hasanefendic et al., 2015). Hasanefendic et al. (2015) highlight the relevance of short-term project-oriented research as a motor towards the institutional credibility, through the engagement of local and external organizations and their commitment in training together with the higher education systems, students that represent the next labour force.

Moreover, UBC creates mutual benefit for all parties involved, contributing to the economic development at regional and national level (Mueller, 2005), as well as meeting the demands of the labour market (Plewa, Galán-Muros & Davey, 2015), providing local businesses with access to research breakthroughs and helping them with problem-solving, by increasing the employability of students (Gunasekara, 2006). Within our specific context of rural SMEs, it is complex for universities to get access to organizations and also to be acknowledged as a strategic partner. The challenge of HEIs is to create instruments that "open up" the university for small companies, increasing open communication and inter-organizational trust (Davey et al., 2011). According to Plewa et al. (2012) the foundations that are drivers of business engagement in the design and delivery of the curriculum at university-business cooperation includes external communication, *alumni networks* and senior management engagement. Thus the development of common knowledge platforms and an understanding of each other's aims are deeply relevant in the construction of these specific projects. Raising awareness about which activities and services are available is considered to be crucial at initial phases of Cooperation Units establishment (Plewa et al., 2012). The authors also advocate that strategic collaborations should be implemented, rather than discrete, ad-hoc or one-way transfers of knowledge or technology. In addition, HEIs are now considered to be operating in markets where it is imperative for them to make use of marketing instruments (external communication) to be successful (Baaken et al., 2016). There are a series of factors that can influence the ability of HEIs or academics to undertake and pursue UBC including specific barriers, drivers and situational factors (such as age, gender, years working in the HEI, years working in business, type of HEI, size of HEI and country). However, the 4 strategic pillars, and conditions for successful UBC can be summarized as the strategies, structures and approaches, activities and framework conditions which can be implemented (action items). These can directly stimulate UBC or indirectly address influencing factors affecting UBC (Davey et al., 2009).

The aim of this paper is to discuss the conditions for UBC (Opportunities and Challenges) and describe the process of creating a University-Business Cooperation (UBC) Unit at ESTG-IPVC (Technology and Management School - Viana do Castelo Polytechnic Institute). The main driver that supported this unit is therefore the belief that undertaking fragmented university-business cooperation activities within university-business cooperation ecosystem needs to be considered towards an overall university-wide approach for collaborating with businesses.

The specific objectives of this paper are:

- to discuss the conditions for UBC at ESTG;
- to explore the relevance of the adoption of a more structured and formal approach to university-business cooperation;
- to describe the creation and organisation of a UBC unit, at this Public Polytechnic (IPVC) at a specific school (ESTG- Technology and Management School).

In the next sections we will present the ESTG and the development process of the unit and the seven axes that are being proposed. These axes capture the different ways in which cooperating initiatives and practices between businesses/institutions and ESTG can occur. Critical factors to take into consideration for the success and improvement of the functioning of business-cooperation units will also be discussed through the paper.

2 ESTG (IPVC) and the Development of the Unit

ESTG is part of IPVC, one of the six existing schools in this Public Polytechnic, created in 1980. ESTG area of activity includes the three components of the so-called knowledge triangle:

• education – provides certified educational offer in different areas, at Professional (level 5), MSc and Master levels;

• research – research activities ranging from basic to applied research with an industry focus, concentrating on trans- and interdisciplinary areas with a strong innovation potential;

• innovation – ESTG aims at developing/reinforcing strong links with the business community to ensure that its work is appropriate for market needs, and its activities are oriented to make it as useful to the economy and the society as possible.

In order to achieve its goals, ESTG strengthens links with the productive sector, establishing partnernvolving companies, organizations and society as a whole, establishing partnerships, sharing objectives, planning and building together the scientific, educational, innovation and social integration design that make up the triple mission of a modern university. The strategic partners are organizations, across a range of sectors, that consider a cooperation with ESTG as a first order opportunity for the achievement of their social goals, as well as their research, development and innovation goals, and whose strengths and ambitions are in line with the School ones, to increase experience-based learning and employment opportunities for our students.

2.1 UBC at ESTG - oportunities and challenges

Over the last years, several initiatives have been put into practice by many of the teachers, namely extra-curricular training and project-based learning (PBL). Taking the academic year of 2016/2017 as example, and the initiatives that are of geater relevance for students skills and employability enhancement, it can be seen that a significant number of PBL, trainig programmes and entreprenership fostering initiatives has been implemented, involving more than 200 students.

Table 1 - Examples of UBC Initiatives at ESTG

Academic year 2016/2017	
Project-Based Learning (PBL)	75
Non-curricular training programmes	50
Curricular Training programmes	97
Entrepreneurship fostering initiatives	14

The Courses with greater involvement on UBC activities are Tourism, Management, Computer Engineering, and Civil Engineering. Some of the initiatives are of a multidisciplinar nature, involving teachers and students from different courses, or from the same course but different disciplines.

In spite of the number and relevance of those initiatives, it is believed the maximization of its full potential still requires a diferent level of organization and communication. In addition, and although many of these initiatives are framed by protocols have been signed between ESTG and several organisations, some of these protools do not have a specific focus. Opportunities for growth exist, namely with alumni that are local and regional entrepreneurs, or in management positions. It is also believed that parternships should be more precisely defined, towards a more efective cooperation, with measurable and sustained results. Probably due to the lack of a common understanding of what can be the organizational strategic guidelines and directives regarding these issues, associated to a lack of an organisatinal structure that ensures resources either human or facilities, there is still work to be done. Providing conditions in order to facilitate the integration of students in the professional context, through practical job placements is often a way of promoting UBC. At ESTG (and other schools from IPVC have already replicated the event) there is already "Emprego IPVC", organized by the student board, aiming at strengthening the articulation between students and the labour market, through the identification of potential job placements and helping businesses to select/recruit the students with the adequate skills. Also this year, IPVC developed the first Job Fair, increasing the institution external communication of resources, abilities and potentials, and establishing new partnerships with different business partners. Another initiative is the creation of a Junior Enterprise at ESTG, a non-profit organization, formed and managed exclusively by students, developing projects, in their study fields, for companies. This initiative intends also to strengthen UBC, and enable students to apply their theoretical knowledge on practice, developing their entrepreneurial skills by running the organization and benefiting from the guidance of teachers and professionals. Junior Enterprises are similar to real companies, counting with the principles of corporate governance like management council and executive board. This possibility has already been discussed with representatives of JADE – European Confederation of Junior Enterprises and Jade Portugal, and it is an on-going process.

3 Operationalization of UBC at ESTG

Considering all that is already being done, and the possibilities ahead, it was considered that cooperation initiatives should be more structured, and a Unit proposed with a clear market driven approach, whose main objective is to proactively facilitate the relationship between organizations and the School (ESTG) based on a continuous relationship through a personalized dialogue. Considering Plewa et al. (2012) and the relevance of the external communication, all the disperse information is combined on a platform, providing all stakeholders with the portfolio and the different ways in which cooperating initiatives and practices between organisations and ESTG can occur. It is expected that the information made available will contribute to enhance cooperation, but most of all, it will work as a showcase of the possible / alternative ways of UBC available at ESTG.

3.1 Similar UBC (Benchmarking / cases studies)

To propose a structure for the Unit, several examples were analysed, namely of institutions providing similar services, but with higher organisational structure and communication platforms. In the European Commission reports (2014), several examples can be found, some of which referring to a context of SMEs, as is the case of ESTG. Some of those examples were considered as best practices and have informed/inspired the organisational structure and communication tools of UBC-ESTG, such as the University of Girona and the University of Wroclaw.

But despite these cases being inspiring and of the existing similarities, UBC at ESTG favours interdisciplinarity at a greater extent. Considering that ESTG hosts set of courses from different disciplinary areas, it is possible to create multidisciplinary teams that approach the projects and challenges of UBC in a holistic way. So it is possible that students from different courses, participate in the same project, at the same time or at subsequent moments.

3.2 Structural model of the UBC-ESTG unit

The structural model of the UBC unit at ESTG includes seven strategic axes, as presented on figure 1. These axes will be explained, in more detail, in the following subsections, with special emphasis being placed on

R+D+I, Training and Project Based Learning, as those that are considered of greater relevance in the development and enhancement of student's skills and employability, whilst contributing to regional social and economic development.

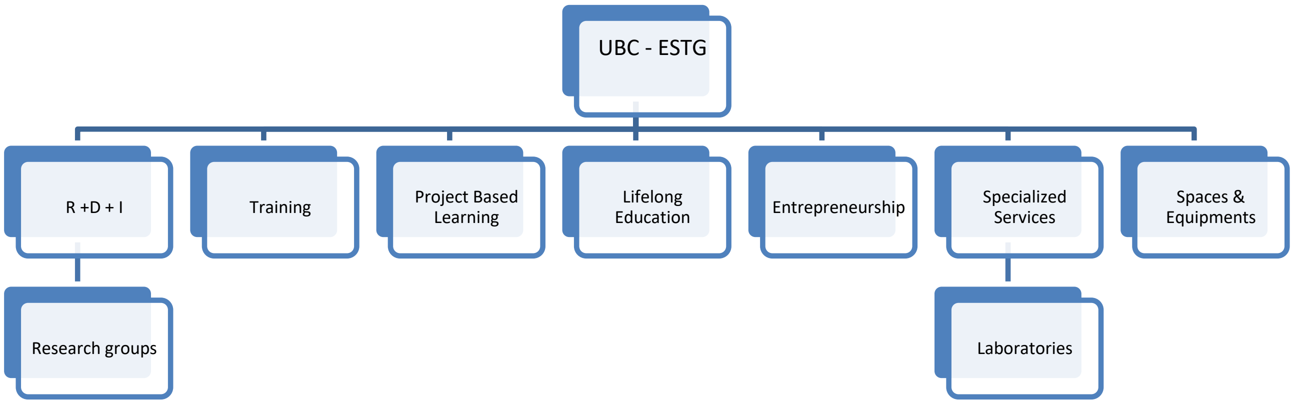

Figure 1: Structural model of the UBC-ESTG unit

3.2.1 R+D+I: Research Units

In the ESTG laboratories, and through collaborative initiatives, research projects or innovative technological solutions can be developed, without SME having to invest in sophisticated facilities and equipment or hire research personnel orienting it to the innovation needed. On the other hand, ESTG/IPVC has a wide experience in the participation of R & D projects in collaboration with companies and institutions, both at national and international level. In addition, master level students' research can be driven by a specific need of a private business or organisation. In a context of real challenge, master students learn to be more motivated and reach higher levels of satisfaction with their research, considering their work has meaningful and valuable to a greater extent.

3.2.2 In Businesses Training Programmes (Talent)

The objective of the training programmes is to allow students to apply and deepen knowledge in the context of their work, acquired through academic achievement. It is intended to promote its integration in the professional world, by providing them with a greater capacity for initiative and adaptation, contributing to high levels of motivation, creativity, flexibility, innovation, communication, organization and decision. Many of these training programmes are of a non-curricular nature, but have shown large scale adherence by students, which translates the value attributed to them as platforms for employability.

3.2.3 Project-Based Learning (PBL)

Project-Based Learning is a teaching method in which students gain knowledge and skills working over a long period of time investigating and responding to an authentic, engaging and complex question, problem or challenge (Christie & de Graff, 2017; Lima et al., 2017). It also seeks to increase the active participation of ESTG in the community, to strengthen and transform theoretical knowledge, to acquire knowledge in a real context, promoting the development of employability and key life skills for the professional and personal development of students.

The objective is to stimulate relations between the different courses available at ESTG, to develop and carry out the students' projects. The projects will be conducted within the curricular units and in close cooperation with the organizations involved, as happens in other HE Institutions, with great emphasis on PBL approaches and the link between university and industry (Dinis-Carvalho et al., 2017; Lima et al., 2015; Lima, Mesquita & Flores, 2014; Mesquita, Lima & Flores, 2013). A coordinator is assigned to each project who then analyses which curricular units can contribute to its problem-solving. After identifying the underlying challenges, the different teachers who integrate and / or have responsibility for PBL are included in the process.

One of the reasons for PBL being so much valued and adopted is associated with its importance for fostering interdisciplinary approaches and student motivation (Lima et al. 2007). Interdisciplinarity is a key feature of PBL at ESTG, as students need to relate different content areas and apply them to a broad scope of projects. Students are also challenged to deal with teamwork and project management, skills which enhance employability.

3.2.4 Lifelong Education and Training

In ESTG/IPVC, the articulation between education and training for life will promote the urban regeneration since people that are vital to future competitiveness of a region. The demand for personalized service jobs and interpersonal/communication skills increased the demand for highly skilled staff and talent. Engagement with higher education provides the skills for specialist, highly productive and well-paid work. Currently, for example, we developed a partnership with a leading pre-fabricated brick company, located at the Viana do Castelo Technology Incubator (VianaTech), and the employment center of Viana do Castelo to promote a training course in the area of BIM (Building Information Modeling) to re-qualify civil engineers and unemployed arquitects, complementing a lack of local and international workers with these abilities.

3.2.5 Entrepreneurship

The objective is to contribute to the development of initiatives that allow projects created by students (including hub 2) to be implemented jointly with partners. These initiatives can be translated through entrepreneurship competitions such as the contest "DNA Empreende com Gestão", "Poliempreende", and the mobilization of investment funds, venture capital, crowdfunding, among others. The project of creating a Junior Enterprise at ESTG is in accordance with this stance.

3.2.6 Specialized services to the community

Providing specialized services to the community is a key vehicle for bringing the ESTG and IPVC closer to the surrounding community, through research and technological development. In this context, the work developed by Innovation and Knowledge Transfer Bureau (OTIC) is of great significance, as this Unit constitutes plays the role that is designated, in the business world, as the commercial role. In fact, among other tasks, OTIC is responsible for establishing contacts with potential clients, identifying their needs and articulate the creation of internal teams. OTIC is also responsible for monitoring these R&D processes to ensure clients final satisfaction, it is important to adapt the "academic timings" to the "business timings", ensuring an effective and efficient response capacity. The increase in the volume of rendered services will include the institutional capacity to strengthen the relationship with organisations throughout more regular contacts and the establishment of a follow-up process. ESTG is already involved in an extensive set of activities of knowledge transfer and support to the community. This is achieved through research groups from the various scientific areas of this school, as well as by its Laboratories directed to the provision of services to the community, in areas as diverse as the environment, civil engineering and food.

3.2.7 Spaces & Equipments

Although ESTG / IPVC] has a modern and functional set of equipment, classrooms and amphitheatres, suitable for various types of events (Seminars, Courses, Workshops, Meetings, Exhibitions, Parties among others) that are available for renting or loan, on a permanent basis, or sporadically, for specific occasions. The underlying conditions (renting or loan) are associated with the profile of the organisations requesting access to equipment and spaces and dependent on the relationship established between them and the School. Quite often facilities are provided without associated costs, materializing the principle of social responsibility and contribution to local development.

4 Conclusion

This paper presents a brief contextualization and diagnosis of the state of the art of different organizational strengths and opportunities at ESTG-IPVC that sustain the creation and development of a strategic school unit, working exclusively on the university-business cooperation. There are several ungrouped initiatives that can be organized and therefore improved, increasing the strategic public positioning of this Polytechnic School. The organisation of working groups, and the identification of a team leader responsible for each area, as well as the creation of marketing tools that provide available information about these thematic areas, will be crucial for the increase of collaborative initiatives and for organisations' acknowledgement about ESTG as a strategic partner. For the academy, this paper intends to explore and discuss the practical challenges found in the operationalization of UBC, contributing to the literature as a contextualized example that describes the rationale and conditions underlying its development process.

With a focus on continuous improvement, not only a series of additional initiatives are being considered, but also assessment procedures are being put into practice at ESTG, to understand the real impact of the UBC unit in specific, and of UBC initiatives to students, teachers and professionals. It is expected future work will include and discuss assessment results.

5 Acknowledgments

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Students' perceptions and motivation in an Industrial Engineering and Management program along their academic journey: first results

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Abstract

An ongoing study about what motivates/demotivates students of an Industrial Engineering and Management (IEM) program will be introduced. The reasons behind students' choice and the main factors that motivate/demotivate them, throughout the different years, will be explored. This study is part of a longitudinal one based on information from IEM students' motivation and perceptions throughout their academic journey (five years). The students anonymously completed an online questionnaire applied in two different moments (end of each semester) to all IEM students. Based on the answers to three open questions ("What motivated me the most?", "What motivated me the least?", "What could contribute to increase my motivation?"), a mix approach will be carried out, to follow students' perceptions, experiences and motivation through their academic years. Also, a question allowing students to rate their motivation in the semester (from "always motivated" to "never motivated") was included. As a first study, 2016/17 academic first year will be analysed. From a population of 334 students, 66 (20%) in the first semester and 64 (19%) in the second semester answered the questionnaire. Although the sample's dimension can difficult the statistical inference, the study revealed some interesting results. Six main categories of motivation/demotivation factors were identified: the program go from the curricular content; companies contact; the learning methodology; teamwork; the teacher-student relationship; the final assessment, the time management, curricular units and the existence of project. An important issue to highlight is the use of active learning approaches which strongly contribute to student's motivation and engagement. The majority of students perceived their motivation as "sometimes motivated" (65% in the first semester and 59% in the second). The diversity of answers to the same questions show how different students are. In general, this can be seen as a drag as, and most of times, students are treated in a standard way, without respecting individual differences. This could be an important aspect to attend when discussing the quality of teaching and dropouts from school.

Keywords: Students' Motivation and engagement, Engineering Education; Learning styles; Industrial Engineering and management program, diversity.

1 Introduction

Motivation is an important trigger to make people to act. In a learning context, and according to Brophy (2004), students' motivation to learn can be viewed either as a general disposition or as a situation-specific state. This author considered that as a disposition, the students value the learning they are capable to learn even if this implies effort. What they want is to acquire knowledge and skills. In specific situations, means that there is a state of motivation to learn an activity. For this, the student engages purposefully and tries to learn the concepts or master the inherent skills.

More than knowledge and skills, motivation will take the students to a point where they develop competencies. According to Rychen & Salganik (2000), competencies is beyond knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilizing psychosocial resources (including skills and attitudes) in a particular context. The notion of competences encompasses not only cognitive but also motivational, ethical, social, and behavioural components. It combines stable traits, learning outcomes (e.g., knowledge and skills), belief-value systems, habits, and other psychological features. From this viewpoint, basic reading, writing and calculating are skills that are critical components of numerous competences (Flumerfelt, Alves, & Khalen, 2014).

The right motivation will pull from the students the development of these kind of competences, including the technical and the transversal competences. As Deci, Vallerand, Pelletier, & Ryan, (1991) point out, when students are highly-motivated they learn in a routinely way (they are willing to), without effort or as a some kind of punishment. It is like they acquire a motivated learning schema, triggered whenever they enter a learning situation. This trigger could be an activity, a teacher, a learning methodology or teaching tool; anything that (even not always like in general disposition), "activate" students to be more motivated. However, students are very different in terms of learning styles which, according to (Felder & Silverman, 1988), are classified into four dimensions, namely: sensing/intuitive, sequential/global, active/reflective and visual/verbal (Figure 9).

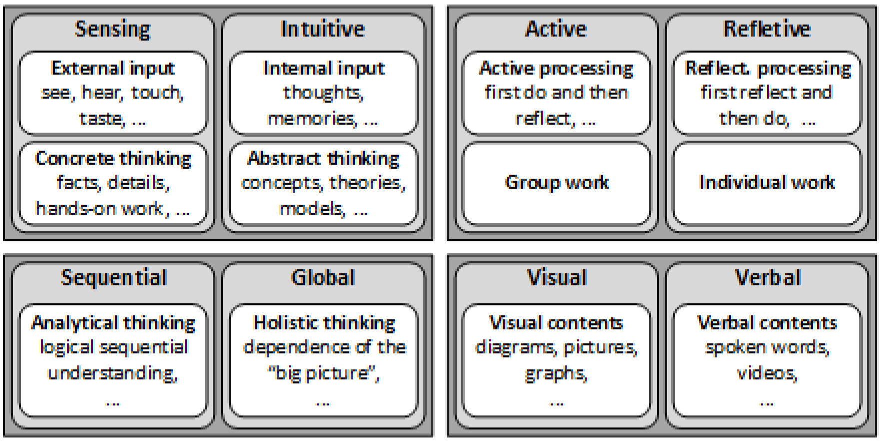


Figure 9. Felder-Silverman model of students' learning styles (Sousa, Moreira, Alves, 2013).

With this in mind and hearing students from Industrial Engineering and Management (IEM) talking and comparing motivation along their different semesters, the authors of this paper propose a survey to collect, during the five years in IEM program, students' opinions in terms of motivation. This is of particular interest as the students will experience different learning methodologies, including three Project-Based Learning (PBL) models in three semesters in a program of 10 semesters. Works and research regarding PBL and how this learning methodology can be used as teaching tool to develop students' motivation to learn are easily available through database search. Namely, how PBL can be used to motivate and increase students' attitudes towards STEM and to develop competences/skills. However, unavailable or insufficient works and research how these skills gained during the PBL project development are used from the point of view of students in subsequent years.

The projects developed under PBL methodology are, most of the times, the meaningful and worthwhile of the learning referred by Deci et al. (1991) found by the IEM students and the trigger to them take seriously where they try to get the benefits from them. Following this idea, the aim of this paper is to present the first results of the research work regarding the study of the students' motivation during their academic journey. A questionnaire was applied in two different moments: end of first semester and end of the second semester of 2016_17. With the questionnaire could be possible to follow the students' perceptions, experiences and motivations accumulated through the years. This study could serve to understand better the students factors motivation and improve the IEM curricular plan in order to increase satisfaction ratio and reduce drop-out that is still a problem in Engineering Education, particularly, in the first year (Holmegaard, Madsen, & Ulriksen, 2016).

This paper is organized in five sections. After this introduction, the second section presents the research methodology in light of the defined and presented research questions. The third section presents briefly the study context focusing the PBL models adopted in the program: IEM11_PBL and IEM4_PBL. Section fourth presents, categorizes, analyses and discusses the motivation survey results. The section five presents some final remarks.

2 Research methodology

To uncover the reasons behind IEM students' motivation during their academic journey, a content analysis was used. The data collected through the students' answers given to the open questions, available in the online questionnaire, were categorized and indexed (Bardin, 2009). This procedure allowed to highlight significant findings.

After the identification of the main purpose of the on-line questionnaire, it present three main parts: (1) students' curricular year and semester identification, (2) Student's perception and motivation, and (3) final question. In part 2, the student identify how he/she felt during the semester by an open question based on a 5-point Likert motivation scale (1- never motivated to 5- always motivated). Next, the set of three open questions, allowing students to explain, in their own words, the degree of motivation regarding the semester: "What motivated me the most?"; "What motivated me the least?"; and "What could contribute to increase my motivation?". Also, students identify one or more reasons behind the decision from choosing the IEM programme at this University, from a predefined list of nine possible reasons, such as, "It was what I intended"; "I had a final score to enter"; "I was not able to enter the program that I wanted", among others.

Due to the nature of some of these questions, also a quantitative analysis was considered in order to measure how many and how motivated students are and if their perceptions and motivation are significantly different between semesters. For this analysis, the SPSS statistical tool (Field, 2009) was used for the data analysis. Non-parametric test was considered on the analysis of the data due to the lack of normality of the data (by the Kolmogorov-Smirnov test): Mann-Whitney U (alternative to the t-test for independent samples), throughout the value of Z-score, to analyze differences between students' perceptions and motivation by year and semester. A significance level of 5% was considered.

In the 2016/17 academic year, a total of 340 students were enrolled in the IEM programme, a total of 38.9% replied to the first call to fill the online questionnaire (19.8% in the first semester and the remaining in the second semester), distributed by academic year according to Figure 2.

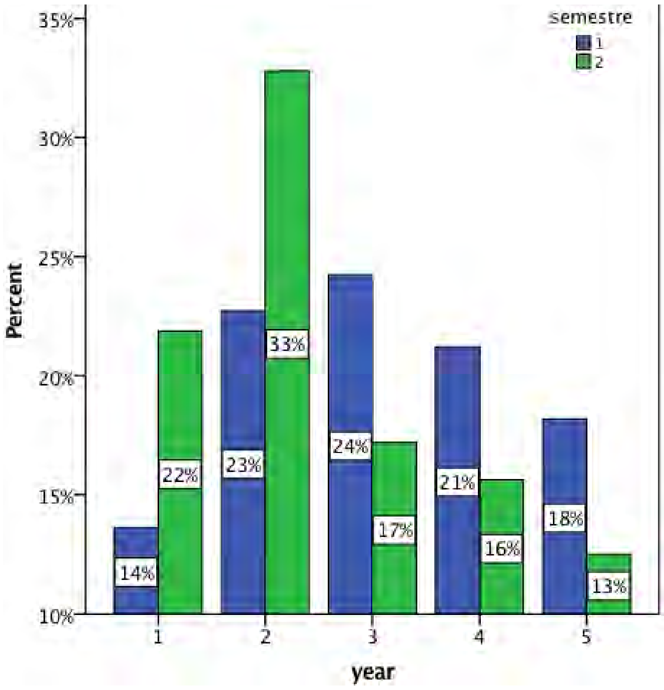


Figure 10. Distributions of respondent students by curricular year and semester

The sample's size could be considered not representative, however, and as a first study of this nature, the findings could reveal interesting and helpful results.

The questionnaire was design based on the following research questions:

- How motivated students are?

- What motivate students the most/least?
- What can be done to contribute to students' motivation?

Notice that all the answers to these research questions will be based from students' own point of view. Due to space constraints, throughout the paper the discussion of the results obtained will be done considering in more detail the first year, corresponding to a 17.7% and the fourth year, corresponding to a 18.5% of the sample of IEM students´ respondents.

3 Study Context

The Industrial Engineering and Management program (IEM) addressed by this study is an Integrated Master Degree with a duration of five years (10 semesters), totalizing 300 ECTS (European Credit Transfer System). Figure 11 represents the curricular structure of the program showing that the unit courses (UC) are classified into four categories: (i) basic sciences (BC), (ii) engineering sciences (EC), (iii) specialty sciences (SC) and (iv) complementary sciences (CC).

One of the distinctive characteristics of this IEM program is the existence of three six-monthly integrated projects (IPIEM – Integrated Project in Industrial Engineering and Management), based on the PBL approach: IPIEM1 (1st year, 1st semester) generally referred above as IEM11_PBL, IPIEM2 (4th year, 1st semester) and IPIEM3 (4th year, 2nd semester), referred as IEM4_PBL. The IPIEM1 and IPIEM2 projects involve all the UC of the semester while IPIEM3 is in fact composed by two projects, each one involving two UC of the semester. All the projects are developed by teams of students (8 to 10 elements), have the support of the teachers of the UC involved (PSC – Project Supporting Courses) and also of a tutor (whose main purpose is to ensure that the project runs smoothly).

<table>
<tr><th>Year</th><th colspan="4">Semester 1</th><th colspan="4">Semester 2</th></tr>
<tr><td>1</td><td colspan="2">BC
(4 UC)</td><td>EC
(1 UC)</td><td>SC
(1 UC)[1]</td><td>BC
(2 UC)</td><td colspan="2">EC
(3 UC)</td><td>CC
(1 UC)</td></tr>
<tr><td>2</td><td>BC
(3 UC)</td><td colspan="2">EC
(2 UC)</td><td>SC
(1 UC)</td><td>BC
(2 UC)</td><td colspan="2">EC
(3 UC)</td><td>CC
(1 UC)</td></tr>
<tr><td>3</td><td>EC
(1UC)</td><td colspan="3">SC
(1UC)</td><td colspan="4">SC
(1UC)</td></tr>
<tr><td>4</td><td colspan="3">SC
(5 UC)</td><td>SC
(1 UC)[2]</td><td colspan="2">SC
(5 UC)</td><td>SC
(1 UC)[3]</td><td>CC
(1UC)</td></tr>
<tr><td>5</td><td colspan="2">SC
(5 UC)</td><td>SC
(1 UC)[4]</td><td>CC
(1 UC)</td><td colspan="4">SC
(1 UC)[4]</td></tr>
</table>

1) Integrated Project of Industrial Engineering and Management I (IPIEM1)
2) Integrated Project of Industrial Engineering and Management II (IPIEM2)
3) Integrated Project of Industrial Engineering and Management II (IPIEM2)
4) Dissertation in Industrial Engineering and Management

Basic Sciences (BC)
Engineering Sciences (EC)
Specialty Sciences (SC)
Complementary Sciences (CC)

Figure 11. IEM curricular structure (scientific areas)

3.1 Integrated Project on Industrial Engineering and Management 1 (IPIEM1)

The Integrated Project on Industrial Engineering and Management 1 (IPIEM1) is a semester-wide multidisciplinary and team-based Project, which uses the Project Based Learning Methodology (PBL). PBL is known to provide an Active Learning experience, which is of special relevance within engineering fields, where learning-by-doing is both valued and encouraged, as it improves the overall learning experience, the retention of knowledge and the development of both technical and transversal skills. The IPIEM1 takes place in the first semester of the first year of the IEM program, which is in fact the students' first learning experience at the University, i.e. in a PBL setting. This normally contrasts with their full prior learning experiences in pre-university education levels, which is essentially supported by teacher-centred activities as opposed to the PBLs' student-centred approach.

The projects are wide and open-ended, i.e. with no unique solution and holding a suitable dimension and complexity, so that a full team of students have to structure the work and conduct relevant activities, so as to tackle the challenge during a full semester. The teams have to comply with strict deliverables deadlines, related to reports, presentations, prototypes and a number of other activities, such as on a number of peer assessments, extended tutorial, industrial visit, specific sessions on transversal competences, e.g. related with teamwork and multimedia presentations, among others.

The PBL teams rely on a wide team of lecturers, mostly related to the Project Supporting Courses (PSCs) that provide technical support on the project specifics throughout the semester, and other lecturers, students (from more advanced years) and education–related researchers, performing a number of support functions somehow linked with the management, execution and improvement of the project – all these persons constitute the so-called Coordination Team. The PSCs pertain to the schools of Sciences and Engineering, distributed by four departments (Maths, Chemistry, Production and Systems, IT). Each one of the PSCs represents 5 European Credit Transfer System (ECTS), amounting to 30 ECTS in total for the semester. The project is multidisciplinary, i.e. the PSCs collaborate, support and provide assessment on the PBL experience. The learning on PSC contents, breed, at least partly, from the problems that spur from within the project challenge, which makes it more close to reality. Table 1 presents the structure of the 1st semester of the IEM degree.

Table 1. Courses of the 1st year, 1st semester, of the IEM program

Acronym	Curricular Unit (Course)	Scientific area/School	ECTS
LA	Linear Algebra	Basic Sciences/Science	5
CC	Calculus C	Basic Sciences/Science	5
GC	General Chemistry	Basic Sciences/Science	5
AP	Algorithms and Programming	Basic Sciences/Engineering	5
IIEM	Introduction to Industrial Engineering and Management	Specialty Sciences/Engineering	5
IPIEM1	Integrated Project on Industrial Engineering and Management I	Engineering Sciences/Engineering	5

The **Error! Reference source not found.** presents the current model of PBL developed in the IPIEM1 and the project supporting courses that are all of the curricular plan.

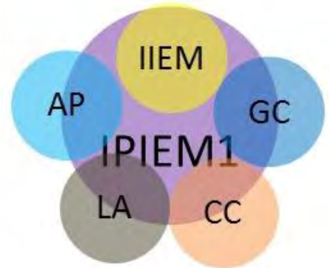


Figure 12. IPIEM1 Project Supporting Courses (2016/17) (Alves et al., n.d.)

Transversal competences are also exercised and improved along the semester, namely given that the teams have to make a number of presentations during the semester, schedule and manage the required set of activities, deal with interpersonal conflicts, exercise brainstorming activities, design experiences, conceive products and production systems, make consistent argumentation around a rationale, work effectively within a team, conduct and direct meetings, assess the work of others (teams and peer colleagues), etc. Figure 1 depicts the IPIEM1 PBL model. All PSCs lecturers of the 1st semester provide input for reaching a project that is somehow meaningful and relevant on their perspective (Moreira, Mesquita, & van Hattum-Janssen, 2011) and relate to Sustainability issues in order to promote its awareness (Alves, Moreira, Leão, & Carvalho, 2017; Colombo, Alves, Hattum-Janssen, & Moreira, 2014; Colombo, Moreira, & Alves, 2015).

The IPIEM1 is conducted by six teams of seven to nine students each. Any given team has its own tutors (one lecturer and one or more 3rd year IEM students). The teams are tentatively gender balanced and hold other fundamental settings equitably (as previously defined by the coordination team). Some insights on these issues can be consulted in Alves, Moreira, & Leão, (2017). The assessment model is rather elaborate, given that all the deliverables are essentially assessed by all the lecturers of the PSCs, and additionally the students are asked themselves to provide assessment on the work of their peers (Moreira et al., 2015, 2017). The process is also the subject of continuous improvement, grounded on the yearly perceptions collected (through a workshop and questionnaires), targeting the stakeholders, namely the students themselves, the lecturers, and the tutors.

3.2 Integrated Project on Industrial Engineering and Management 2 IPIEM2

As the IPIEM1, the Integrated Project on Industrial Engineering and Management 2 (IPIEM2) is a semester-wide multidisciplinary and team-based project, which uses the PBL. However, the IPIEM2 is developed in industrial context and each team works in a specific company. The project involves all the course units of the semester (Figure 13) and has two phases: (i) analysis and diagnosis of the production system and (ii) development of improvement proposals.

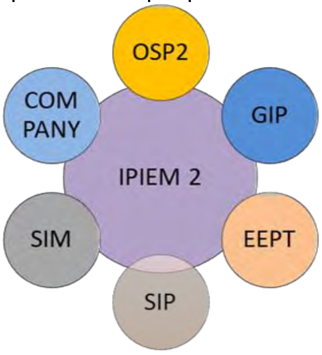


Figure 13. IPIEM2 Project Supporting Courses (2016/17) (Lima, Mesquita, Dinis-Carvalho, & Sousa, 2015).

The PSCs are: Production Systems Organization II (OSP2), Production Information Systems (SIP), Simulation (SIM), Ergonomic Studies for Workstations (EEPT), and Production Integrated Management (GIP). Dealing with real problems in industrial scenarios is a major asset to students.

3.3 Integrated Project on Industrial Engineering and Management 3 IPIEM3

In 2016/17, the Integrated Project on Industrial Engineering and Management 3 (IPIEM3) was in fact composed of two projects: one involving the PSCs Reliability and Maintenance (RM) and Complements of Quality Engineering and Management (CQEM) and other with the PSCs Computer Aided Manufacturing (CAM) and Computer Aided Design - Computer Aided Process Planning (CAD-CAPP). Both projects involve the PBL methodology but with quite different approaches. The first project is totally team-based while the in second one students play one of two roles: customer or supplier. The customer is always an individual but the supplier can be an individual (freelancer) or a team of individuals (supplier company). In general terms, the project establishes a network of customers and suppliers where the first ones launch jobs / tasks into the market and the second ones apply to execute those jobs / tasks in a competitive environment.

4 Motivation survey results and discussion

This section presents the main quantitative and qualitative results of the survey. Table 2 shows the main descriptive statics (mean, standard deviation, minimum, maximum and median of the students' motivation scores) by academic year and semester regarding how motivated students are (based on a 5-point Likert motivation scale from 1- never motivated to 5- always motivated). In average, students indicated to be "sometimes motivated" ($\approx$4), with lower value in the second semester of the 2nd and 4th year (mean=3.20 and median=3). None of the students indicated to be "never motivated" (1), conversely, some students identified to be "always motivated" (5). There is a tendency to find students more motivated in the first semester (1st) compared with the second semester (2nd), but only in the 4th year that this tendency is statistically significant ($Z=2.62$, $p<.005$).

Trying to understand this tendency, several dimensions were identified from the data analysis: the program go from the curricular content; companies contact; the learning methodology; teamwork; the teacher-student relationship; the final assessment, the time management, curricular units and the existence of project.

Table 2. Descriptive Statistics by academic year and semester regarding how motivated students are

Year	Sem.	n	Mean	s.d.	Min	Max	Median	Test statistics (1st – 2nd) Z	p
1st	1st	9	3.89	.33	3	4	4	.61	.54
	2nd	14	3.71	.73	2	5	4		
2nd	1st	15	3.20	1.01	2	5	3	.84	.40
	2nd	21	3.48	.81	2	5	4		
3rd	1st	16	4.00	.52	3	5	4	.45	.65
	2nd	11	3.91	.54	3	5	4		
4th	1st	14	4.29	.61	3	5	4	2.62	< .005
	2nd	10	3.20	1.03	2	3	3		
5th	1st	12	4.08	.52	3	5	4	.17	.91
	2nd	8	4.13	.35	4	5	4		

s.d.: standard deviation

The most recent theories of behavioral economics present motivation as an incremental, developmental process in which challenge, effort and recognition are objective and undeniable dimensions in the development of the motivation process (Norton, Mochon, & Ariely, 2011). In these results, students' motivation when they have curricular units that work on Project Based Learning, especially the 1st and 4th year, is different from the rest of the years (Figure 6). The 1st semester, on the 1st year students recognized that the effort in overcoming challenges are motivational indicators of the process of meaning construction, related to the development of project tasks. The development of meaning is a very relevant dimension in the motivational process. Students identify the lack of perceived individual meaning of theoretical lectures and the disarticulation among final project evaluation. This is another factor that prevents the construction of individual meaning. The lack of congruence constitutes a very relevant difficulty in the development of shared meaning, becoming a serious obstacle to the motivational process.

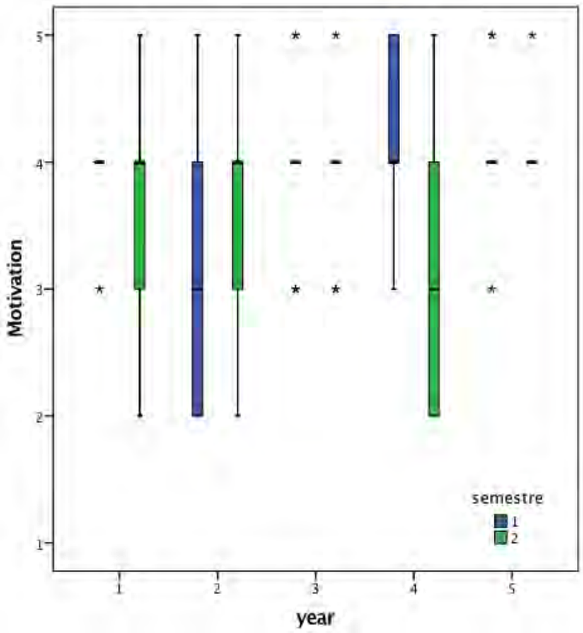


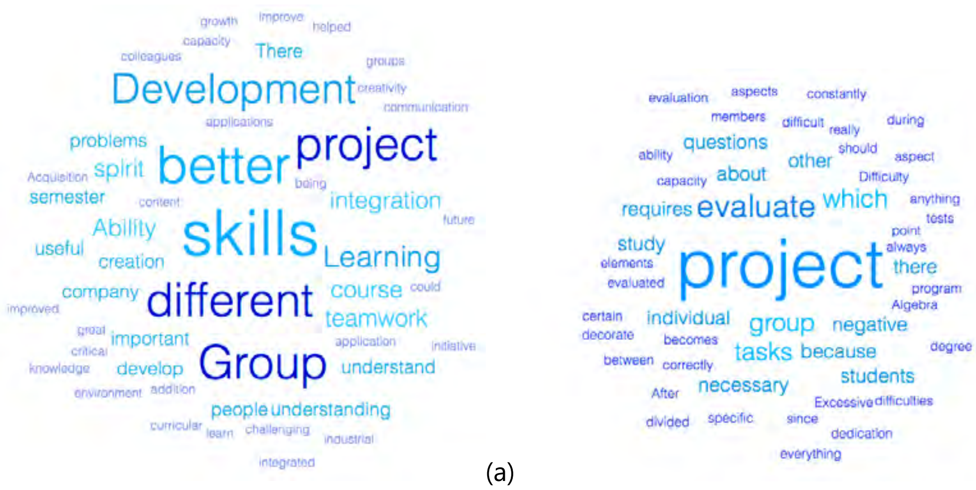
Figure 14. "How motivated students are": students' answers distribution, 1- never motivated to 5- always motivated, academic year 2016/17, by semester.

The results of Norton, Mochon, & Ariely (2011) show that these incremental motivational processes, provided by a high rate of effort and challenge, constitute even higher predictors of the theory when challenges are presented to newcomers to the tasks. The 1st year, 1st semester constitutes a group especially prone to motivational development for Project-Based Learning, as it is their first experience in higher education. It is still relevant to note that according to this theory the motivational result incremented only happens if the result of the task is positive, in this case if the student has been successful in the challenge presented, or if their work and high effort have been successful in completing the tasks. Time management is another dimension that emerged and that referred to, as well as the evaluation methodology, may have been perceived by the students as obstacles that diminished the reach of the motivational incremental process. It is considered that those are relevant factors. At the same time, they are elements that constitute incongruence and cognitive dissonance in the attributional process necessary for the development of motivation in the student.

The qualitative analysis of the justifications put forward by the 2nd semester students clearly show a marked difference between then and the 1st semester students' motivation. The results show a great relevance of the evaluation, serious difficulties in the teaching-learning process (noise, expository lectures, uninteresting) problems in the teacher-student relationship and in the methodologies used. In this second semester the qualitative results present a focus on the final evaluation, in the final grades. To analyze these results, we suggest Bailey's (Bailey, & Garner, 2010) perspective that presents a central aspect in this matter, the idea that when students are very focused on their grades, their intrinsic motivation is low. The results no longer show a focus on the challenge, effort and overcoming that led to the results showed in the discourses of the first semester. In the second semester we find no meaning, no involvement in the learning process. It was also found criticism and anguish.

Results from the 4th year, that also have curricular units focusing on projects show again this relevant difference perceived qualitatively by the students, where they show a higher engagement and motivation on the first semester and again it decreases on the second.

The students' words usage and frequency can be visualized supporting the previous analyses and discussion of the results. Figure 7 shows the words used by students regarding what motivate them more and less. The obtained figures were obtained by simply count the words with more than five characters without taken into account the previous nor the following words (Neri de Souza, Costa, & Moreira, 2011). The positive words like "skills", "development", "group", "learning" were used to identify students' motivation. Conversely, words like "evaluate", "tasks", were used to identify students' lower motivation. Interesting to point out that the word "project" was used in both situations. May be due to the work required during their development, being either a positive or negative aspect of their work.



(a) (b)

Figure 15. Word cloud of written students' answers to (a) "What motivated me the most", (b) "What motivated me the least?"

5 Conclusion

This paper intends to explore and understand motivations and demotivation of Industrial Engineering and Management (IEM) program students. Despite the quantitative analysis of the 1st year students' motivation does not spell out significant differences between both semesters, qualitatively, the reasons given by students, present relevant arguments. It is relevant to invest in understanding specifically the flow of motivations during the program considering that motivation is not a static dimension. In this paper, it was also discussed the relevance of the motivations flow and try to begin the exploration of the concept on this specific population of students. It is also clear that more qualitative works are needed in this subject, considering that qualitative results show high differences between semesters. It is clear from the results for the 4th year in the IPIEM2 project that deals with real problems in industrial scenarios, is a major asset to students, motivating and engaging them. This is a preliminary study just for an academic year but interesting results were obtained confirming some ideas and raising others which demands a deepness of this study, namely, to know the relationship with the methodologies used and learning styles of each student. Regarding this last aspect, it would be interesting to submit students to the online questionnaire prepared by Richard Felder and Barbara Soloman (https://www.webtools.ncsu.edu/learningstyles/) that allows the identification of students learning styles. Debates and future works about the quality and efficiency of the learning/educational system should take all these results into consideration.

6 Acknowledgments

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EFEI, an interdisciplinary cowork in the Engineering Faculty – University of Magallanes – Chile

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Abstract

This article reports the experience of the collaboration between four departments of the Engineering Faculty at the University of Magallanes, during the implementation of a common project. The main objective of this project is to improve and update the higher education processes in the undergraduate programs offered by the faculty. In 2016, an interdisciplinary team self-styled EFEI-UMAG (Strengthening Team for the Engineering Education at the University of Magallanes) was formed by faculty members of the Computer Science, Chemical, Mechanical and Construction Engineering Departments inside the Engineering Faculty. This team convened with the goal to collaborate in the development of products that can be used in the training of the professionals, the research at university teaching and the self-education of their members. During the first year, the EFEI-UMAG was trained in Problem-Based Learning (PBL). The objective was to begin its implementation inside the different core courses offered by the faculty. Work meetings were coordinated with the different representatives of the industrial area; and, information on case problems was collected so they could be included in the core courses and those that are of interest for the companies. As result of these activities, concrete products were obtained such as set of cases and/or problems of the many branches of engineering. These can be used as incomes for the implementation of PBL in the faculty. Moreover, a PBL implementation manual was written for the faculty members who wish to begin to use this method in their classes in the future. Currently, in 2017, PBL is included in many core courses of the Engineering Faculty, and the first results have shown a positive evaluation both by academics and by students.

Keywords: Higher Education Interdisciplinary Problem-Based Learning.

1 Introduction

In its final edition of 2015, the Forbes magazine specialized in business and finance highlighted the following ten compulsory work skills for a XXI century professional: 1) teamwork, 2) problem solving, 3) effective communication, 4) organization, 5) data processing and analyzing, 6) quantitative data analyzing, 7) technical knowledge related to work, 8) proficiency in software programs and language, 9) report writing and editing and 10) sales and marketing.

From the perspective of the relationship between higher education and the productive sector, according to (Villa & Poblete, 2007): a) in the workplace, the capacity of solving complex problems and contributing to alternative solutions it is a quality indicator of a good professional, b) in the educational sector, problem solving makes possible many types of thinking such as analytical, systematic and creative. Problems usually require a teamwork resolution. Besides, it improves the research capacity and the knowledge and know-how development, respectively.

Specifically, in the educational sphere, a newer teaching method on engineering – initially implemented on the health area – is Problem Based Learning (PBL) proposed by Barrows (Barrows, 1986); that defines PBL as a learning method based in the principle of using problems as a start-up point for acquiring and integrating new knowledge. According to (Escribano & Del Valle, 2008), the fundamental features of PBL, established by Barrows among others, are: i) problems are the focus of organization and stimulation for learning, ii) problems are a vehicle for the development of problem solving skills and iii) new information is acquired through self-directed learning.

Since 2010, the University of Magallanes (UMag) has started an action plan to improve gradually the training quality delivered in its thirty-one (31) undergraduate programs. One of the activities aimed to encourage their faculty members to be trained in the use of different pedagogical techniques of teaching-learning process inside the classroom. In particular, in the academical departments of the Engineering Faculty (FI-UMag) naturally appears the necessity to improve in the following aspects: i) Vinculacion con el medio (community engagement) and regional framework, ii) incorporation of real problems to the engineer Syllabus, iii) techniques that involve a comprehensive development of the future engineer, where soft skills are strengthened and iv) to consider the local industry opinions about the graduated engineer profile.

It is in this context and with the aim of bringing improvement in the teaching-learning process of the future engineer that the current and future industry demands, Universidad de Magallanes carried out the Equipo de Fortalecimiento a la Educación en Ingeniería UMag, (EFEI-UMag), (Building Team for Engineering Education at UMag).

This article accounts this joint initiative, which it is generated as interdepartmental, and it is oriented towards updating and improving the training teaching tools considering the regional context of the university and its environment.

2 EFEI and its track record

The track record done by EFEI-UMag is shown in figure 1:

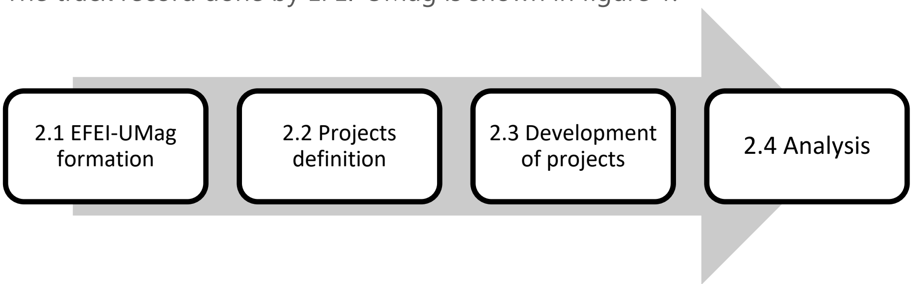

Figure 16. EFEI-UMag track record scheme.

2.1 EFEI-UMag formation

Aware of the need to self-training and continuous improvement related to the areas of teaching and teaching research, an interdepartmental and interdisciplinary self-styled team EFEI-UMag was formed in 2016. The team is made up by eight (08) teachers of the academical departments of Chemical Engineering (02), Computational and Informatics Engineering (02), Construction Engineering (02), Mechanical Engineering (01) and Physics and Mathematics (01). Initially, EFEI-UMag established that its actions had to be addressed to the quality process improvement of the teaching-learning process of undergraduate students of FI-UMAG in a collaborative environment and support among its members. Thus, it was agreed that the goals of this team are: a) to collaborate in the developing products to be used in the formation of the graduated engineer profile, b) to research about the teaching-learning process, and c) to implement improvements in the pedagogical approach.

The strategy used to achieve its goals, as a team, was the self-training and self-education of its members. In this way, the academic activity that motivated the formation of EFEI-UMag was the attendance and active participation of two (02) of its members at the workshops about the PBL method training, which was inside the Newton Picarte Project "Building skills in STEM (Science, Technology, Engineering and Mathematics) to improve the socioeconomical development in regional Chile" (Berres et al., 2016). Such training is a final product of the research developed by (Maldonado, 2017) which corresponds to a pilot teachers training of engineering faculties from south Chile carried out by the collaboration of Universidad Católica de Temuco and the University of Strathclyde, Scotland.

EFEI-UMag considers, because of its transversality, that the PBL teaching-learning method is a perfect start-up to initiate a research process in the field of Engineering Teaching. One of the reasons of this selection is justified in the fact that PBL, as method, includes a direct connection with the compulsory skills required by the working world which will be part of the graduated engineers of our university.

In this context, EFEI-UMag defined the following actions to reach the established goals for the period 2016-2017: 1) to initiate research activities on university engineering teaching, 2) to do training in the PBL method to EFEI-UMag members and later to others FI-UMag teachers and 3) to create feasible set of case-problems from real situations of the local productive sector to be used as income of PBL method.

Figure 17. Teachers participating in a group dynamic which consist of building the tallest tower with plastic straws (participants experiment and reflect about: teamwork, critical thinking, leadership, effective communication, initiative/proactivity, problem solving, and assessment)

2.2 Projects definition

In order to formally and institutionally begin teamwork, EFEI-UMag members elaborate, present and are awarded proposals (teaching projects) in an internal contest called Teaching Developing Fund (FONAD) that is convened annually by the UMag Teaching Unit (unit that supports the developing of projects related to teaching improvement). The awarded projects were developed in a collaborative manner and its final product compromised was to design a database of case-problems and to write a brief manual (Lagos & Maldonado, 2016) as essential income to implement PBL in some core courses in the training of engineers.

To design the database of case-problems, EFEI-UMag met with company representatives and relevant industries of the region, where current graduates of FI-UMag work, and the following five (05) suggested questions in (Maldonado, 2017) were asked: 1) What are the biggest technical challenges that your company faces? 2) What do you think is going to be the next biggest technical challenge by year 2050? 3) If a recent graduated engineer begins to work for your company tomorrow, Which functions or type of problems will you invite him/her to solve? 4) What is it the structure that exists inside your company to face research and innovative issues? And 5) If the best worldwide engineering consulting could work for you for free to solve a problem in your company What problem would it be?

2.3 Development of Teaching Projects

Based on the results of the meetings and interviews made to 24 productive local sector representatives and considering the steps to create a case-problem proposed by (Tien et al., 2005), which it is shown in the following scheme:

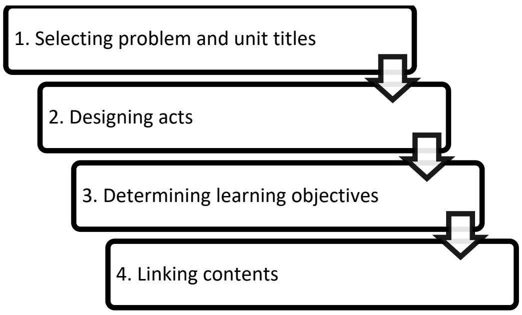

Figure 18. Scheme of process to create a problem-case according to (Tien et al.,2005)

38 case-problems proposals were obtained: a) 06 for ionic equilibrium laboratory (chemical engineering), b) 03 for fluid mechanics (mechanical engineering), c) 19 for fundamentals of the construction laboratory (construction engineering) and d) 10 for the areas of informatics, informatics management, administrative information systems, programming and networks. Below a case-problem for each discipline was shown:

2.3.1 Chemical Engineering

A SME called "Cultivos María" is applying for a greenhouse irrigation project. During the application filling, a debate was generated about the type of water to be used as a supplier. The two alternatives are: (i)drinking water and (ii)river water from a river nearby. Analyzing the implementation costs, the investors realized that the costs were similar. So, they consult to a chemical engineer respect to which water supply is better. The professional suggests that the salts dissolved in the water can help or damage the crops.

Therefore, the investors request to the chemical engineer to take a sample of each water supply and determine the hardness of each water sample in the laboratory. Due to his load work, he decides to ask his group for help to determine the hardness of the drinking water and the river water and to conclude which of the two is best to cropping.

2.3.2 Mechanical Engineering

In the Chilean tenth region it is assessing to install a geothermal power plant. In its design, the plant takes a fluid of high enthalpy that rises naturally through a pipe from inside the ground. This fluid is being used to spin a turbine. The condensate is reused to heat isopentane in a secondary circuit that allows to spin a second turbine. After heating isopentane, hot water at 100ºC is obtained, which has to be returned to the natural reservoir inside the ground.

It is requested to evaluate the eventual usage of this water for housing, in a population of 500 inhabitants living at 3 km of distance from the geothermal power plant. There is almost no difference between the level of the plant and the town. It is required: i) to estimate preliminary about the feasibility of the residual water usage for housing, ii) to estimate heat loss (c/km) of the pipe and the quantity of isolation to use in function of the pipe diameter, iii) to estimate the necessary flow (and adequate) to satisfy the water demand, iv) to do a brief research of the pumps required to transport this fluid (consider the liquid has high amount of solid materials) What type of pumps will you used? What type of filters? What diameter would be the appropriate for transport? v) In a first stage, What would it be the basic parameters to estimate the Project cost? And, vi) Is the project profitable? What is its cost? Make a comparison with conventional energy.

2.3.3 Construction Engineering

In a mining company dedicated to coal extraction there are many working areas. One of them is specifically intended to small machinery maintenance and repair of until 30 tons. It is at the same time in charge of a subcontract. This subcontract carries out its tasks outdoor, which has generated several observations by the health and safety department, as they work near pedestrian traffic areas, handle oil lubricants and chemical products that pollutes the soil, as too does the obtained residues from cut tools, without mentioning their exposition to the weather conditions. Therefore, the same workers have demanded a solution to this problem. This situation has been assigned to you as construction engineer from the infrastructure department to undertake a construction management of a storehouse taking into consideration the following aspects: i) required work area: 1000 m2, ii) minimum height required: 4 meters.

a) What constructive solution can you offer to solve this problem?

b) What considerations and features should have with the structure required?

2.3.4 Computational and Informatics Engineering

The restaurant 'Los Ganaderos' wants to update its way of taking their clients orders. To do this, its restaurant owner has requested to an IT services company the design of an App of which clients can order through their mobile phones sitting on their table, and the orders will arrive directly to their kitchens. This is the idea of the owner and he request to analyze and assess its feasibility and implementation in his/her restaurant.

2.4 Analysis

2.4.1 EFEI-UMAG member characterization

Table 1 shows EFEI-UMag profile:

Table 2. EFEI-UMAG profile members:

Profession	Teaching experience (years)	Core courses lecturer
Chemical Engineer	03	Computational Simulation of Processes, Unit Operations, Laboratory of Processes, Computational Applications in Chemical Engineering
Bachelor in Chemistry	15	General Chemistry, Laboratory Techniques, Environment and Environmental Monitoring, Ionic Balance
Mechanical Engineer	03	Fluid Mechanics
Civil Engineer	04	Soil Mechanics, Reinforced Concrete, Structural Analysis
Construction Engineer	09	Fundamentals of the Construction, Cost analysis and Budgeting, Material Resistance
Computational and Informatics Engineer	15	Management Information Systems, Development of IT Systems, Computation Applied
Electrical Engineer	15	C Topics, Computer Systems Engineering, Computer Organization
Mathematical Engineer	14	Linear Optimization, Numerical Calculus, General Mathematics

The tasks done by the members, allowed consolidating competences associated to the teacher role of each professional members of EFEI-UMag. In particular, according to the indicated descriptors in (Villa & Poblete, 2007), the competency of teamwork is acquired in its three domain levels: "1) to participate and actively collaborate in team assignments and to build confidence, cordiality and orientation towards conjunction task, 2) to contribute in the team consolidation and development, to favor the communication, to the balanced division of tasks, internal environment and cohesion, and 3) to lead working groups assuring the integration of its members and they orientation towards a high performance."

2.4.2 Representatives of the local productive sector

Meetings with local representatives of the productive sector were conducted independently inside the UMag facilities. The main features of the attendees of each meeting were:

a) Chemical Engineering: 03 chemical engineers working in the areas of methanol production, brewery and Higher Education.

b) Mechanical Engineering: 06 mechanical engineers and 01 electrical engineer .They work in the areas of transport, operation and gas production, higher education and services.

c) Construction Engineering: 10 construction engineers, 01 civil constructor and 01 topographer. They mainly work in the areas of local construction companies and independent contracting.

d) Informatics and Computational Engineering: participants belong to the various services offered in the region such as hospitality and restaurant entrepreneurs, regional advisers, gendarmerie, health and municipal.

2.4.3 Regarding the meetings between EFEI-Umag members and representatives of local productive sector

With the goal to data collection for case-problems proposal elaborations, interviewing was used as field technique.

Table 3. Field technique used.

Area	Type of interview	# of events
Chemical Engineering	Group (conversational)	01
Mechanical Engineering	Individual	03
Construction Engineering	Group (conversational)	01

Informatics and Computational Engineering	Group (conversational)	01

The template instrument used for the field research was a survey with five suggested questions in (Maldonado, 2017). However, other questions were also considered because of each Project interest:

Table 4. Additional questions.

Area	Questions
Chemical Engineering	What are the major technical challenges that your company is facing in the laboratory area?
Mechanical Engineering	What problems of the industry are presented and can be brought to the classroom? What typical problems have you had in the industry?
Construction Engineering	What are the most common problems that the "Construction Engineer" is faced in their professional practice? What kind of situations the professional can be compromised in the technical and / or ethical field?
Informatics and Computational Engineering	What have been the computing problems in your companies? How have you faced them?

The interviews conducted made possible to know in a better way the daily labor experiences that graduated professional from UMag are facing. For example: 1) in the hospitality/restaurant area, the major difficulty it is due to that computational programs are purchased abroad. In case of requesting after-sale services, the communication fails because our local network connection is unstable. 2) the beer production process, it is required to know the type of raw material, the difference between rest alcohol and fermented alcohol and the microbiological analyses related, 3) In the laboratory standards interpretation, it is required to bring into practice physicochemical analysis procedure from a standard in order to make solutions in adequate volumes accordingly to what it is necessary. Also, technical English reading of international standards and how to implement it in quality laboratory management is required. And 4) in the gas extraction, there are designed equipment between 1959-1962 that were acquired as second hand.

2.4.4 About a pilot PBL implementation experience

By using the proposal of generic competences evaluation that appears in (Villa & Poblete, 2007), it is shown – in Table 3- the following preliminary results observed in the PBL implementation as teaching method in the core courses: SUBJECT 1, SUBJECT 2.

Table 5. Generic competences identified in PBL pilot implementation results.

Competence	**Proficiency competence level**	**PBL relationship**
Analytical thinking	Describe, relate and interpret simple situations and approaches	Problem reading, brainstorming
	Significant elements selection and their relationship with complex situations	Ideas categorization, previous knowledge, problem definition
	Lack of information identification and relation establishment with external elements of propose situation	Investigation, discussion and generalization
Problem Solving	Identify and analyze a problem to generate alternative solutions by applying learnt methods	Knowledge application
	Proposal and construction solutions in teams in diverse aspects, with a global vision	Assessment

Teamwork	Participation and actively collaboration with team assignments and promotes confidence, cordiality and orientation towards joint task	Contract elaboration, brainstorming and ideas categorization
	Contribution to team consolidation and development, favoring communication, balanced distribution, internal climate and cohesion	Compliance of the different team functions
	Leadership in teamwork, assuring members integration and orientation to a higher performance	Team coordination

3 Reflection and conclusion

This article reflects the joint effort made by an interdisciplinary team of engineers regarding its university teacher's role and the teaching-learning process at the Engineering Faculty of the University of Magallanes. The team has taken the initiative to address and research the many pedagogical methodologies currently used in the training of engineers. It has been opted, as first stage, by the PBL method since the majority of the core courses are currently using problem and/or project solving to integrate the acquired knowledge that the students obtain.

It may be noted that the joint collaboration was not exempt of difficulties. One of the main issues was time management, which is presented by the many academical commitments that every university teacher must take care besides the important task of teaching.

This collaborative work has led to approach the academy to some concrete problems of the local productive sector, obtaining positive results as from the regional company representatives that attended to meetings, as the feedback what it is going to nurture to new graduate engineers. Particularly, a contribution of this experience was the relationship produced between the Engineering Faculty and some local companies, which not only strengthened the undergraduate programs, but also promotes the engagement with the regional environment, revealing to these last the capacity that the Engineering Faculty possess in disciplinary issues.

Attention should also be drawn that EFEI-UMag is a way to encourage the active interdisciplinary participation among faculty members of all the engineering undergraduate programs, where the same problem can be dealt with by different disciplines from different angles and also, from different levels of difficulty.

Finally, as futures tasks, EFEI-UMag expects to continue with: a) Improvement of the aspects related with teaching and teaching research, b) PBL implementation from first year in common core courses of engineering students, and c) to strengthen linkage with companies, such it can be a permanent source of updating in formation of our students.

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Minor in Entrepreneurship: A Problem and Project Based Learning Strategy for Training UNIFEI Engineering Students in Technology, Innovation, Entrepreneurship and Social Responsibility (TIES)

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Abstract

It is unquestionable that professional development problems occur less or more intensely throughout the world. More than technical skills in a specific area, it is desirable for the professional to present managerial skills as well as personal attributes such as: teamwork, leadership, human relations, creativity, adapting to change, ethics, honesty, learning to learn, working under pressure and motivation. Such attributes are also found in successful entrepreneurs. In line with the complexity of today's work environment, the Project Based Learning (PjBL) and Problem Based Learning (PmBL) are useful strategies for developing future professionals that are capable to work beyond technical knowledge. In practice, the PmBL and PjBLis based in the fact that the learning process is most effective when the student is the central element of it, when there is an active interaction of the classes with the practice. Another important aspect of these approaches is that they can and have been applied in several different areas and levels. The University Federal of Itajubá (UNIFEI) offers the Minor on Entrepreneurship, a 300 hours program for undergraduate engineering students. Its main objective is developing entrepreneurial and managerial skills by exposing participants in several projects that includes Technology, Innovation, Entrepreneurship and Social Responsibility (TIES). Firstly, this paper intends to compare PjBL, PmBL and Entrepreneurship Education (EE) and its use to improve engineering education. Secondly, it presents in details the UNIFEI`s case: The Minor on Entrepreneurship. Finally, it presents the participants opinion in how these PBL activities impacted in their formation as well as expectations in their future career.

Keywords: Project Based Learning; Entrepreneurship Education (EE); Minor on Entrepreneurship.

1 Introduction

In the past decades, the world has undergone significant changes, such as globalization, the advent and dissemination of the Internet, and all other technologies that have revolutionized communication, how to run a business and access. (Allen, Duch & Groh, 2001). Consequently, Pereira and Rodrigues (2013) affirm the working environment is constantly changing and consequently leading to increasing unpredictability and the need to deal with this context of uncertainty. Adding to it the exposition to an increasingly competitive and demanding market. As a result, these changes trigger effects requires engineers and other professionals with a set of new working environment, such as teamwork, communication, leadership and problem solving.

In agreement with Pereira and Rodrigues (2013), Ritter et al (2017) reported that:

> *As the focus shifts to the inclusion of soft skills as areas of importance, higher education institutions that adequately prepare students in these areas create a distinct advantage that is directly related to increased student achievement such as employment and professional success (according to the AACU, GMAC and NACE employee surveys).*

For this reason, it is also necessary make use of learning strategies that besides transferring information and knowledge it also offers opportunities for students develops demanded skills and attributes. Therefore, this work aims to contribute to the understanding of the process of training people through specialized programs.

Considering the importance of complementary training, this article proposes to analyse in a case study how the PmBL, PjBL and the Complementary Formation influenced the students' lives, and how this process contributes to their professional life.

In order, to better understand these programs, the following objectives were defined:

- Compare PmBL, PjBL and EE and its use to improve engineering education;
- To present the case of UNIFEI in all its details;
- To verify how the process of Complementary Formation based on an active learning strategy influenced the formation of the participating students.

2 THEORETICAL FOUNDATIONS

2.1 Project-Based Learning (PjBL) and Problem-Based Learning (PmBL)

Barge (2010) defines Problem and Project as:

A problem can be theoretical, practical, social, technical, symbolic-cultural and/or scientific and grows out of students' wondering within different disciplines and professional environments. The problem is the starting point directing the students' learning process and situates the learning in a context. A chosen problem has to be exemplary. The problem may involve an interdisciplinary approach in both the analysis and solving phases (p.7).
A project is a complex effort that necessitates an analysis of the target (problem analysis) and that must be planned and managed, because of desired changes that are to be carried out in people's surroundings, organization, knowledge, and attitude to life; it involves a new, complex task or problem; it extends beyond traditional organizations and knowledge; it must be completed at a point in time determined in advance. Projects are necessarily diverse with regard to scope and specific definition. No one specific template or standard exists to define "sufficiency" but rather, these determinations are made within each program (p.7).
According with the same author, Aalborg University has an agreed-upon and clearly articulated vision for how problem and project based pedagogies are integrated into its institutional objectives. In implementing the Aalborg Problem and Project Based Learning Model, the institution demonstrates an ongoing commitment to its central principles: **problem orientation** – Problems/wonderings appropriate to the study program serve as the basis for the learning process; b) **project organization -** The project stands as both the means through which the students address the problem and the primary means by which students achieve the articulated educational objectives. The project is a multi-faceted and often extended sequence of tasks culminating in a final work product; c) integration of theory and practice, participant direction; d) a team-based approach; e) collaboration; f) feedback (Barge, 2010, p.9).

PmBL is a relatively new methodology that has been implemented by many schools and universities. The PBL is an approach to the curriculum structurer, a qualification of students and practice problems. (BOUD; FELETTI, 1997). It is based on the conviction that the learning process is more effective when the student is the central element of teaching, actively participating in the lessons and learning in practice, not just in theory as it was for many years, that is, it is a way of preparation or student for a professional practice. Given its efficiency, Savery (2015) found that this instrumental approach has been successfully applied for over 30 years.

According to Barrows (1996), the PmBL method has these characteristics: (1) student-centered methodology; (2) the process is done in smaller groups; (3) teachers act as tutors or guides; (4) the problems are the organizational focus and the stimulus to knowledge; (5) self-directed learning; and (6) problems are a vehicle for the development of clinical problem-solving skills.

Fernandes (2014) acknowledges that interdisciplinarity is also a fundamental feature of the PjBL, since it qualifies and applies different thematic areas to solve large scale open projects, linking theory to practice. In addition, Fernandes (2014) presents several studies that affirm PjBL as an important strategy to reduce students dropout increase approval for fist year engineering students.

According to Duch, Groh & Allen (2001) with PmBL practice, the student develops the following skills: (a) Critical thinking and being able to analyze and solve complex real-world problems; (b) Find, evaluate and use appropriate learning resources; (c) Working cooperatively in teams and small groups; (d) Demonstrate flexibility and effective communication skills; and (e) Use knowledge of content and intellectual skills acquired at the university to become continuous.

2.2 Entrepreneurship Education (EE)

In the current capitalist productive system, companies are considered a fundamental agent for the generation of jobs in society. For the creation of companies, it is necessary for a person or a group to decide on this, in this context emerges the entrepreneur.

The ability to create jobs, reduce unemployment and create an economic "boom" is among the main reasons why many countries are promoting and realizing the importance of entrepreneurship in education (NIAN, BAKAR, ISLAM, 2014).

According to McMullan (1988) apud (NIAN; BAKAR; ISLAM, 2014), education is an important element for the economic development of a country and entrepreneurship is one of the main factors supporting the community. However, the reality is that many entrepreneurs fail in their business because of the lack of knowledge, skills and entrepreneurial attitudes that are needed to thrive in business during the economic downturn. Many managers face challenges, not because of the lack of opportunities and resources, but because they don't have the needed skills (NIAN, BAKAR, ISLAM, 2014).

The academic environment should contribute to the development of this entrepreneur, through methodologies that allow reform and revolutionize the teaching standard, aiming to contemplate the development of soft skills, so that professionals have the current training required.

According to Gibb (1993, p. 2 apud Fowler, 1997), a very important point is that, traditional teaching methodologies don't apply to Entrepreneurship. Traditional education, at all levels, is established to train people to work in a pre-established structure. It is necessary to train potential autonomous and creative entrepreneurs in a practical way, to create and run their own jobs.

According to Fowler (1997), Enterprise Education Programs aim to develop the skills and attributes of an entrepreneurial individual and not necessarily just to create a profitable business.

2.3 PmBL X PjBL X EE

Barrows (1996) states that throughout the 80s and 90s, PmBL approaches and curriculums were developed in many others areas of education, ranging from kindergarten through grade 12th to university and professional levels, like engineering areas.

> *The method is perceived as the solution to many problems in education, such as the current tendency to produce students who can not think or solve problems and who are bored with education. (...) there are many teachers who use problem-based learning in many disciplines and professions and at many different educational levels around the world, and numbers will increase as teachers see what PBL can do (BARROWS, 1996).*

In addition, several studies reckon that the PjBL is an important strategy that helps reduce dropout rates in schools and increase approval ratings for first year engineering students (Powell, & Weenk, 2003; Lima, Carvalho, Flores & Hattum-Janssen, 2007).

Entrepreneurship Education (EE) emerges as a learning process that helps young people to develop skills and motivation to become entrepreneurs (ASHMORE et al, 2010).

It is used to provide entrepreneurial knowledge and skills to help students succeed in their careers (NIAN BAKAR AND ISLAM, 2014). In addition to assisting career success, according to Fowler (1997), EE provides the individual to attain higher degrees of personal fulfilment and social well-being.

One of the pillars of entrepreneurship education is the PmBL as "learning that results from the process of working towards understanding a problem solving [...] found first in the learning process", according to Barrows and Tamblyn (1980). The PmBL prepares students to think critically and analytically, and to find and use appropriate learning resources. "

Fowler (1997) states that entrepreneur is an individual that creates and manages projects. Aligned with PjBL, EE make use of project as the main cornerstone of the learning process. EE is one of the alternatives that can be undertaken aiming at combating unemployment, because through it people have a real knowledge of the nature of small companies, their importance, dynamism, challenges, advantages and range of opportunities.

This approach not only emphasizes the acquisition of technical knowledge, but also the development of skills in relation to specific and entrepreneurial skills. (Audretsch, 2002 apud Bourgeois, 2011)

2.4 Complementary Training: Minor in Entrepreneurship

To supply this need in today's market, universities have implemented academic programs denominated Minor in Entrepreneurship, which is a term that refers to an entrepreneurial teaching methodology disseminated in several teaching units around the world that apply it in different ways, but with the same principles. An example is the Tulane University, located in New Orleans in the United States, which, through social innovation and interdisciplinary social entrepreneurship, prepares its students for the job market oriented to solve any problem. By merging theory and practice, they create and stimulate research in all fields, in order to create new models of social change (Monhartova; Otten; Faughna, 2010)

The Nanyang Technological University, in Singapore, describes Minor in Entrepreneurship as a transforming learning experience and demonstrates that entrepreneurship is not just about starting new business but also about developing leaders and dedicated professionals, who can identify the opportunities that come with changes in the job market, innovate in planning techniques and execute management processes in different types of organizations (Nanyang Technopreneurship Center, 2011).

Several engineering institutions have been concerned with the implementation of complementary training in entrepreneurship. I 2001 the Journal of Engineering Education of the American Association of Engineering Educacion issued a specific session devoted for papers about Entrepreneurship in Engineering Education (Fredholm; Krejcarek; Krumholz; Linquist; Munson; Schiffman; Bourne, 2002).

3 Case Study: UNIFEI Minor in Entrepreneurship

3.1 The Program: A Startup Journey

The Complementary Training program at UNIFEI is provided to supplement the training of engineers and scientists undergraduate students. This practice is known internationally as Minor in Entrepreneurship in Problem-Based Learning. The program has started in 2012. As it is not an obligatory only few students accomplish the whole program.

At UNIFEI, the students enrolled in this process must complete the following steps:

1. To attend the subjects of Creation of New Business Ideas (Business Model Generation-BMG, Design Thinking, Lean Startup, Effectuation, Prototyping, Pit Presentation, and Costumer Validation): and Introduction to Entrepreneurship (Creativity, Oral Communication, Vison and Relationship, Team Working, Learning to Learn and Search for Information);
2. Take three possible journeys: Business, Maker or Developer (Programming). In Business, the student may choose to study subjects such as Entrepreneurship, Idea Creation and Lean Startup, Social Entrepreneurship, Marketing, Product Development, Costs and Finances. For Maker and Developer journeys, in turn, product development, product management, embedded systems development laboratories offered, for example. All of these disciplines are implemented with PmBL or PjBL methodologies. Each subject has around 48hs/semester with 3 credits.
3. To participate in the SEBRAE (Brazilian Service For Small Business Development) University Challenge at least one year;

4. To participate, at least once, in some extension activities organized by the UNIFEI Entrepreneurship Center, such as Bota Pra Fazer (Entrepreneurship throughout Social Responsibility Projects)-60hs, Maker Hacklab (Development of Business Idea with Internet of Things and Arduino prototyping – a maker competition)-120hs, Maker Startup Weekend Unifei (Development of Business Idea prototyping with Arduino – a maker competition) -54hs, etc;
5. To perform the Final Undergraduation Project (FUP) with focus on startup (FUP *Startuper)* or technical project that proposes a technological innovation with market potential (FUP Disruptive)-160hs.

Once all these steps are completed, the student receives a complementary degree in Entrepreneurship recognized by the University.

3.2 Current Results

The results were obtained by questionnaires and were divided in two moments: with the students who completed the process and with the students who still are in the process.

3.2.1 The students who completed the process

As an analysis tool, all the four (4) students who already completed the process answered an in-depth survey, where the following results can be obtained:

75% of the graduates of the Program are male, aged between 20 and 24 years. And 25% of the population surveyed are females aged 26 years. The preferred entrepreneurship was Business with 75% of the students participating in it, 66% of which are students of the Control and Automation Engineering course, and 33% refer to the Computer Science course. 25% of those who opted to travel the way through the Maker journey are referred to the Electrical Engineering course. [Chart 1 and Chart 2].

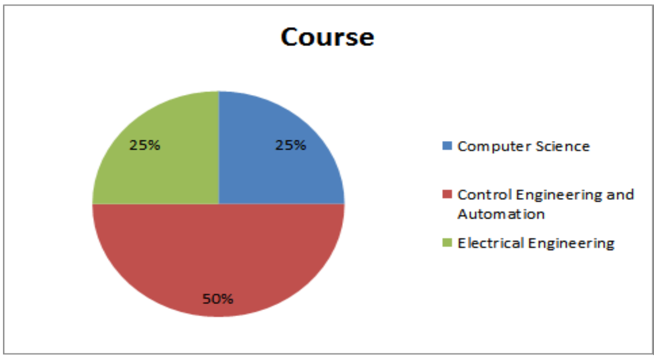
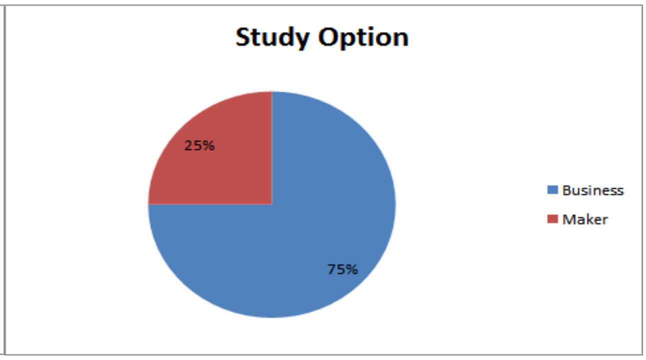


Chart 1. Students



Chat 2. Study

Regarding the reasons for undertaking the Minor in entrepreneurship, 45% of respondents who answered the survey based on the Likert scale, aimed to develop entrepreneurial skills, followed by having contact with entrepreneurship.

Concerning the personal development that they obtained in this process, the most developed skills were: planning, involvement, teamwork and concepts for business creation and management. That is, with this analysis, it is possible to prove that the students who go through this process had their expectations reached. The x-axis represents the skills and y-axis quantifies how people developed skills from 0 to 5 [Graph 3].

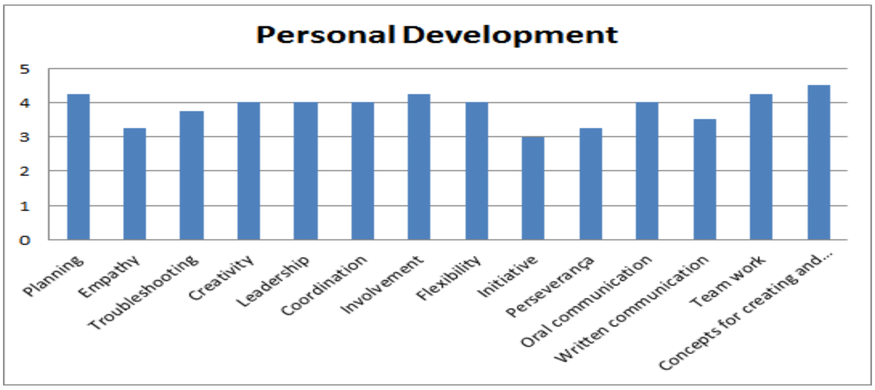


Chart 3. Skills Developed

In relation to the in depth research with these students, it aim to understand how the Complementary Training could help them in the new working environment. The comments were:

"The program favours the development of many entrepreneurial skills, [...] which is a well-known differential in market."
"The complementary training, [...] broadens their vision and knowledge regarding the financial part, organizational structure and analysis of proposals. In addition, in selective processes, theories of group dynamics taught in the entrepreneurship classes were very useful."
"It gives differential comparing with the university traditional curriculum."
"[...] I believe that it brings management experience even before my graduation, a characteristic sought in companies for positions of greater responsibility"
"The training will help me in the capacity for innovating within a company and in the management part of it, an area that interests me a lot. Moreover, having the entrepreneurial engineer training will certainly help me to have a differential in market."
Concisely, it was the consensus of the students that the Complementary Training at UNIFEI offers a differential for developing personal, managerial and entrepreneurial skills, which are desired in professionals in market.

3.2.2 The students who still are in the process

Were collected 40 responses from students who are in the Complementary Training process. The profile of these students are: Most of the students are from Computer Engineering courses, followed by Mechanical Engineering, Environmental Engineering and Information Systems. Most of them estimated to complete their courses between 2020 and 2019, which happens by the fact that students seek to participate in the

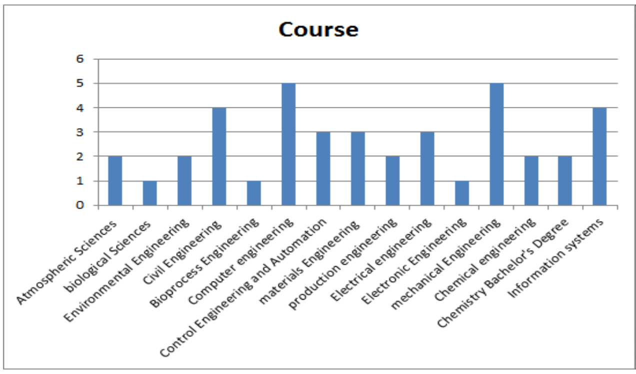


Chart 4. Student

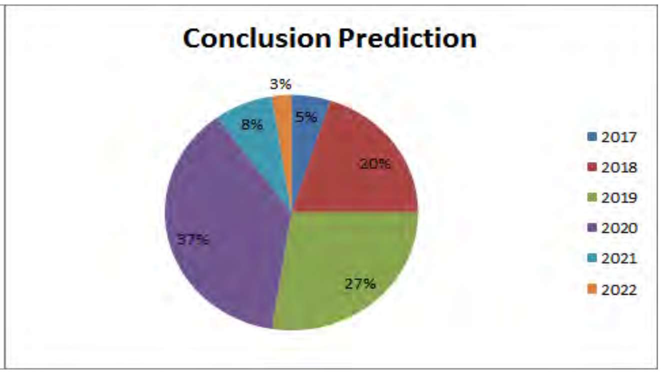


Chart 5. Student Course

Complementary Training from the middle to the end of their graduation. The x-axis represents the courses and the y-axis shows the amount people in these courses. [Chart 4 and Chart 5].

They are more interested in traveling through Business journey, with 79% preference [Chart 6].They were interested in owning the Minor in Entrepreneurship, for the most part, to develop entrepreneurial skills, to have contact with entrepreneurship and to improve the curriculum [Chart 7].

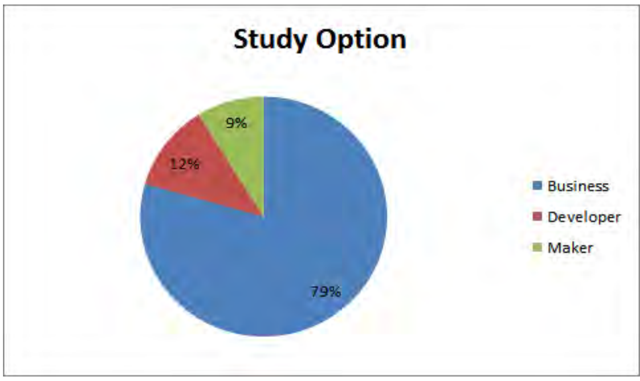


Chart 6 Study

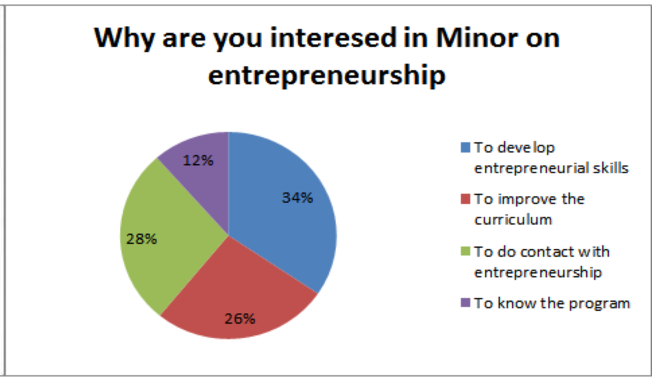


Chart 7. Interest in the minor in

Among the students interviewed who are in the process of Complementary Education, a student has already completed about 88% of the course, against 18 students who are in 38% in progress of the program [Chart 8].

Regarding their current self-evaluation, students consider that the skills they most need to develop are: Planning, Writing Communication, and Concepts for business creation and management. The x-axis represents the skills and y-axis quantifies how people has been developed skills from 0 to 5 [Chart 9].

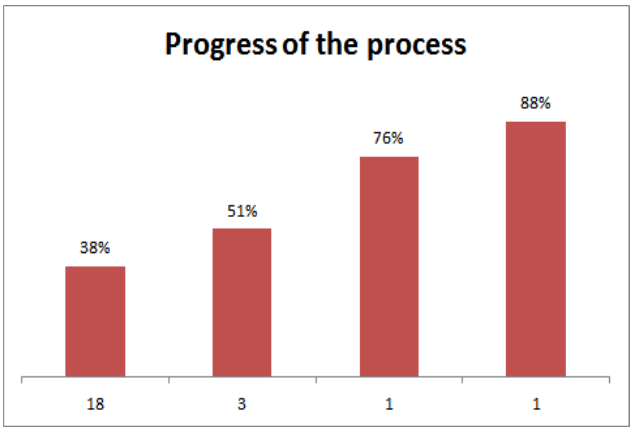


Chart 8. Stage Progress

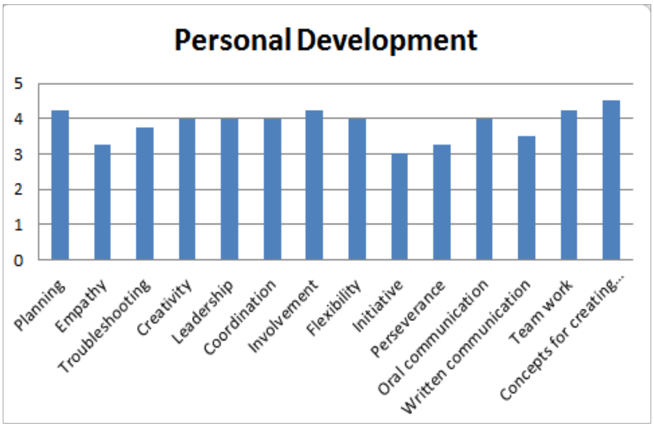


Chart 9. Desired Skills

4 Conclusions

This work had as its objective to present the UNIFEI's case, as well as compare the PmBL, PJBL and their effectiveness for improving engineering education. Adding to it, verify how the process of Complementary Training has influenced the development of the participating students.

The Minor of Entrepreneurship from UNIFEI has its foundations based on Technology, Innovation, Entrepreneurship, and Social Responsibility (TIES). It utilizes Entrepreneurship Education as mean to development of personal skills, demanded in the new working environment.

In order to analyse the results, a research was carried out with students that completed the journey and with the students who are yet in the process.

With this work, was possible to perceive that in spite of some different strategies the PmBL, PjBL and EE have several similarities and certainly, common objectives for learning and developing purposes. It would be interesting to promote events to involve the participation of scholars and researches from the three areas in order to share and increase knowledge.

Comparing the results among the students who are in the process with the students who had already completed it in is possible to infer that, the aiming objectives of the Minor were accomplished. For instance, students are enrolled in the program wishing to improve their planning, communication and project management skills affirm they achieved this goal in the program.

This work has its limitations for analysis due its recent implementation and consequently the small number of concluding participants. It is recommended continuing the interviews in order to improve the knowledge by tracking the future professional career of the graduates of minor.

Finally, this article reached its objectives of analysis and concluded that the program increases entrepreneurship fundamentals in the training of students, reaches the expectations of the students and prepares students to become professionals that meet the needs of the working environment, not necessarily as an entrepreneur but as well as an *startuper* (Technological Entrepreneur)

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Engineering Education (Research) in Higher Education Institutions

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Abstract

The past decades the interest in Engineering Education (EE) and Engineering Education Research (EER) has been increasing all around the world. Nevertheless, educators and researchers in engineering schools that dedicate their time to this field of applied research often find themselves in a reverse flow with the most accepted and traditional career paths. Considering that engineering educators are practitioners of EE and sometimes also researchers in EER subfields, this discussion paper aims to take a snapshot of the state of the art with respect to EE and EER in higher education and the role of higher education institutions (HEI). The approach chosen was to make an exploratory study based on document research, using three main sources: Elsevier Scopus indexing service, Times Higher education university rankings and universities' web sites. Considering the Scopus database, the time threshold was defined as 1970 to the present. Using the search-term "engineering education" it was possible to identify 60250 conference documents and 18610 journal documents. Moreover, it could be established that seven from the top 25 institutions with a higher number of journal publications were also among the top 25 HEI of the Times ranking. Additionally, in all Times Top 25 HEI some kind of organization unit dedicated to staff development could be identified, most of these with some specific organizational initiatives related to EE. Based on this exploratory study the authors conclude that EE and EER mutually benefit from each other and that the combination apparently poses no stumbling blocks to the most recognized research institutions in the world. Finally, the authors argue that this field of applied research potentially has a high impact in the advancement of engineering education.

Keywords: Engineering Education; Engineering Education Research; Active Learning; Project-Based Learning.

1 Introduction

Engineering Education (EE) is gaining an incremental interest in the last years all over the world (Besterfield-Sacre, Cox, Borrego, Beddoes, & Zhu, 2014; Borrego & Bernhard, 2011). This interest is based on the need to improve the education of engineers that should be able to solve complex problems and deal with the engineering challenges (NAE, 2008; UNESCO, 2010). The interest in improving the training of engineers create the need to change engineer education. Changing engineer schools can be based on the five pillars presented by Goldberg and Somerville (2014): joy, trust, courage, openness, collaboration. New approaches should bring joy to students and teachers, and trust is the main ingredient for enjoying teaching and learning, and also for creating an atmosphere of empathy and openness that is necessary for collaboration. In order to create innovative approaches, the stakeholders need a trusting environment. Finally, only courage allows dealing with the natural insecurity that will always accompany a changing environment.

The improvement of a sub-area of knowledge is related to the quality of research developed in this domain. Regarding Engineering Education Research (EER), Borrego & Bernhard (2011) argue that this has now been established as a field of inquiry. Although EER methods and processes can be seen as different from research in engineering (Borrego, 2007), it is strongly linked to the engineering field itself (Bernhard, 2015) and to the improvement of education of engineers. In this line of thought, the National Science Foundation of the USA has a division focused on Engineering Education Centres, investing in the "creation of 21st century engineers and the discovery of new technologies through transformational centre-based research, research in education and inclusion, and research opportunities for students and teachers" (NSF, 2017). This global movement still has opposition in many engineering schools. The statements of the managers and teachers of these institutions are usually aligned with the perceived need to improve engineering education. Nevertheless, there is different perspective about what this means and it could be said that most, or at least a large percentage, of engineering teachers do not recognise the real importance of this field and of the emerging research in this field.

The importance of the results of innovation in engineering education (or in education, higher education, science education or technology education) have been underlined by numerous works: Active Learning (Bonwell & Eison, 1991; Christie & de Graaff, 2017; Freeman et al., 2014; Prince, 2004); Problem and Project-Based Learning (PBL) (Aquere, Mesquita, Lima, Monteiro, & Zindel, 2012; Graaff & Kolmos, 2003; Lima, Dinis-Carvalho, Sousa, Arezes, & Mesquita, 2017; Reis, Barbalho, & Zanette, 2017). Still there is a need to understand to what extent recognised higher education institutions (HEI) are contributing to the field of engineering education research (EER) and to practice improvement in engineering education (EE). This discussion paper aims to take a snapshot of the present state of EE and EER and the role of higher education institutions (HEI). The approach chosen to make this exploratory study, was based on documental research, using three main sources, Elsevier Scopus indexing service, Times Higher education university rankings and universities' web sites.

2 Methodology

Considering the objective defined for this work, and the lack of similar studies an exploratory approach was chosen. Exploratory research approach aims to give first inputs for analysis of fields under research, which allows to create conditions for future in depth studies. In this exploratory study, the approaches selected for data collection were higher education institutions (HEI) sites and articles published in journals indexed in Scopus.

For the bibliometric analysis we used the Scopus database and for the analysis of HEI we used the Times Higher Education ranking for selection of HEI and the web sites for analysis of specific data. The research data collection and analysis were based on the following steps executed at 2017/07/28:

1. Search the database with the following term (using the double quotes): "Engineering education"
2. Analyse the results considering source types, affiliation, authors and countries.
3. Select journals as data source of documents.
4. Select documents after and including 1970.
5. Identify the top 25 bibliometric HEI in this list.
6. Select the top 25 ranking HEI of the Times ranking
7. Search web sites of this Top 25 ranking HEI for centres of Engineering Education or staff development.
8. Cross relate top bibliometric 25 with top 25 ranking HEIs.

The search results showed 18996 documents since 1877, being 386 prior to 1970. Thus, this paper uses the bibliometric data from 18610 documents. Table 6 presents a summary of the documents published since 1970 related to engineering education.

Table 6: Scopus indexed documents published since 1970 – search results of the term "engineering education"

Source type	Numbers
Conference Proceedings	60250
Journals	18610
Book Series	3470
Trade Publications	1648
Books	416
Reports	150
Total	**84544**

3 Findings

The research developed in this work aims to present an overview about HEI contributing to publishing journal papers on EER as a perspective on research in this field, and cross relate this data with the institutions that have Centres of Engineering Education and/or Staff Development, and this way are showing that they are working on the improvement of engineering education practice.

3.1 Higher Education Institutions publishing in EER

The Scopus search results showed 160 institutions with 25 or more papers published in journals, since 1970. Cross relating this results with the Times ranking it was possible to identify in this list, 17 of the Top 25 HEI of the ranking. Figure 19 presents the evolution of publications from 1970 to 2016, showing a steady increment and a high increment since 2009.

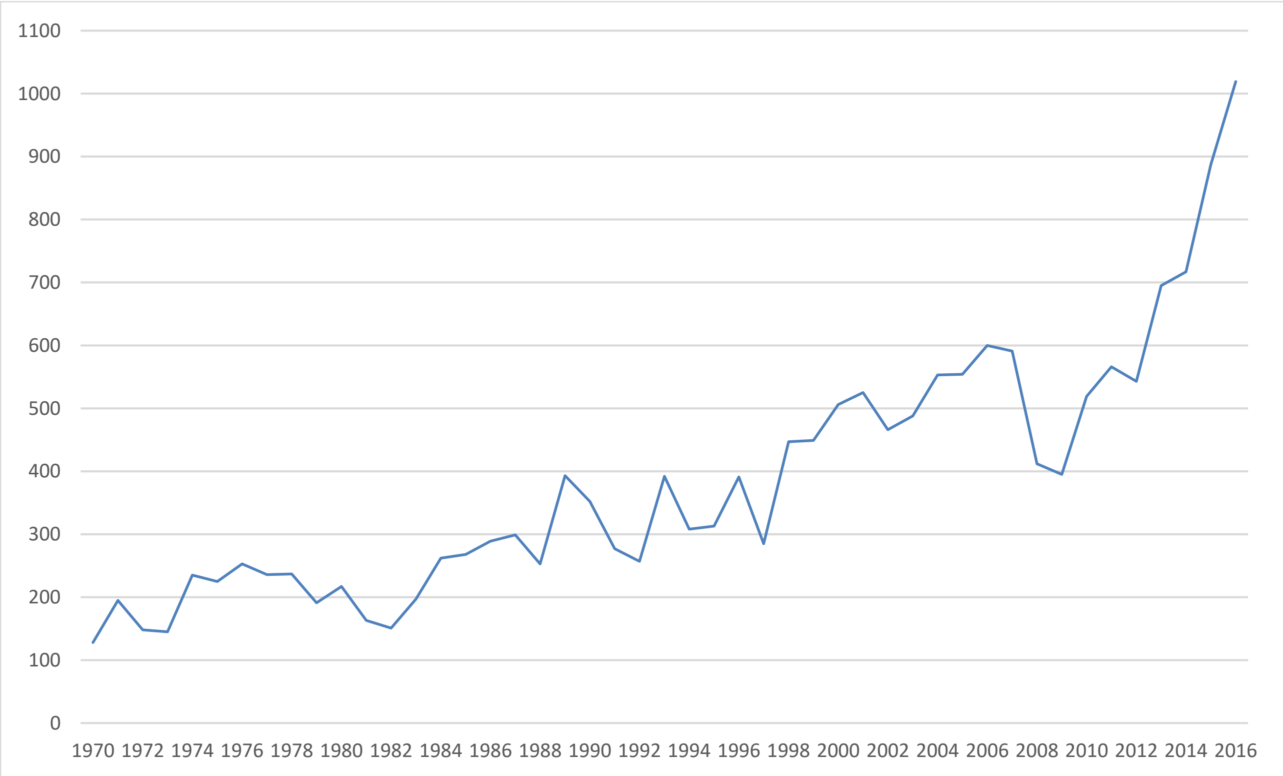

Figure 19: Evolution of the number of publications from 1970 to 2016

Moreover, a selection of the Top 25 bibliometric (step 5 of the methodology) was created and presented in Table 7. In this table it is possible to identify 7 of the Times Top 25. Purdue University is by far the HEI with the highest number of published papers in the EER field. Furthermore, some of the most renowned HEI have been publishing in this area of research since 1970 and are simultaneously being recognised as highly rated institutes in the Times ranking.

Considering that this analysis has a large number of years, a new analysis was made for the last 5 years, since 2012, in order to identify new HEI with a high amount of recent publications. In this new analysis it was possible to identify the following HEI entering in the Top 25 bibliometric:

- Aalborg Universitet
- Utah State University
- University of Ljubljana
- National Taiwan Normal University
- Chalmers University of Technology
- Oregon State University
- Universidad de Salamanca
- Universidad Nacional de Educacion a Distancia

- Queensland University of Technology QUT
- National Taiwan University
- The Royal Institute of Technology KTH
- Universidade do Minho

Table 7: Top 25 HEI with papers published in journals since 1970

#	AFFILIATION	Number of papers	World rank
1	Purdue University	298	70
2	IEEE *	203	
3	Pennsylvania State University	185	13
4	Virginia Polytechnic Institute and State University	163	251
5	Georgia Institute of Technology	144	33
6	University of Texas at Austin	120	50
7	University of Washington Seattle	117	25
8	Massachusetts Institute of Technology	117	5
9	Texas A and M University	112	169
10	North Carolina State University	111	201
11	Arizona State University	109	131
12	Carnegie Mellon University	100	23
13	Stanford University	97	3
14	Universidad Politecnica de Madrid	96	601
15	Iowa State University	88	351
16	University Michigan Ann Arbor	84	21
17	Technion - Israel Institute of Technology	83	301
18	University of Manchester	82	55
19	University of Wisconsin Madison	82	45
20	Delft University of Technology	77	59
21	Missouri University of Science and Technology	72	501
22	Nanyang Technological University	70	54
23	Rensselaer Polytechnic Institute	67	251
24	Loughborough University	66	301
25	Universitat Politecnica de Catalunya	66	401
26	University of Florida	66	134
27	UC Berkeley	66	10

* IEEE is listed as affiliation of authors but is not a HEI.

Going a bit deeper in the analysis of the publications, it was possible to identify the top 10 authors publishing papers related to the term “Engineering Education” in journals indexed in Scopus. This list presents 12 authors in Table 8. Additionally, it was possible to analyse the original education area of these authors, based on a web search developed on January, 1st 2018. Considering the 12 authors’ Bachelor or Master degree, there is only one author that has not originally an engineering degree.

Table 8: Top 10 authors with papers published in journals

#	Name	Number of papers	Area (Bachelor or Master degree)
1	Borrego, M.	37	Mechanical Engineering
2	Wald, M.	36	Engineering - Math and physics
3	Dym, C.L.	26	Engineering design
4	Atman, C.J.	25	Industrial Engineering
5	Ohland, M.W.	24	Mechanical Engineering
6	Besterfield-Sacre, M.	23	Industrial Engineering
6	Pudlowski, Z.J.	23	Electrical Engineering
8	Kolmos, A.	22	Social Science and Psychology

9	Felder, R.M.	20	Chemistry Engineering
10	Finelli, C.J.	18	Electrical Engineering
10	Adams, R.S.	18	Mechanical Engineering
10	Case, J.M.	18	Chemical Engineering

3.2 Centres of Engineering Education and/or Staff Development

An analysis of the Centres of Engineering Education and/or Staff Development in the Times Top 25 was developed, in order to understand if the HEI have specific organizational units to improve the engineering education practice. The overall results are presented in Table 9.

It was possible to identify, in every HEI in the Times Top 25 at least one organizational unit related specifically to engineering education (Type 1), or one organizational unit related to staff development (Type 2) or one initiative to develop innovation in learning that is institutionalized in the HEI website (Type 3). It was possible to identify 31 units in the 25 HEI. The analysis of these 31 units, allowed to identify 13 from Type 1, 14 from Type 2, and 4 from Type 3. Additionally, at least 5 of these units are explicitly linked to human Resources management, incorporating processes of career development or staff hiring. Three of these HEI refer to Networking units that involve several HEI, being two of them the same unit.

An analysis of the main information presented in the websites was developed in order to understand the main mission and activities of these units. One of the main characteristics of the mission statements (or general objectives) of these units are to support higher education teachers in improving their teaching effectiveness, in order to improve learning. In this way, teachers can easily access services and training related to teaching different audiences with different profiles. These services and training opportunities give support to designing, planning and delivering classes, and to curricular design or restructuring. Additionally, it helps teachers to improve the way they deal with the teaching – research nexus and with the outreach activities. Some of these units have explicit links with undergraduate students.

Table 9: Centres of Engineering Education or Staff Development in the Times Top 25

Rank	Higher Education Institution	Education support
1	University of Oxford United Kingdom	Training & development https://www.ox.ac.uk/staff/working_at_oxford/training_development?wssl=1
2	California Institute of Technology United States	Caltech Center for Teaching, Learning, & Outreach (CTLO) https://www.ctlo.caltech.edu/
3	Stanford University United States	Cardinal at work https://cardinalatwork.stanford.edu/learn-grow
4	University of Cambridge United Kingdom	CETE Center of Excellence for Technology Education (network) http://www.cete-net.com/home/?no_cache=1
5	MIT United States	Teaching and Learning Lab (http://tll.mit.edu/about/who-we-are-and-what-we-do) Communication Lab (http://mitcommlab.mit.edu/about-us/)
6	Harvard University United States	Office of Faculty Development & Diversity https://faculty.harvard.edu/about
7	Princeton University United States	Keller Center for Innovation in Engineering Education https://kellercenter.princeton.edu/
8	Imperial College London United Kingdom	Education and teaching support https://www.imperial.ac.uk/engineering/staff/education-and-teaching-support/
9	ETH Zurich Switzerland	Educational Development and Technology (LET) https://www.ethz.ch/en/the-eth-zurich/organisation/departments/educational-development-and-technology.html
10	University of California, Berkeley United States	Center for Teaching & Learning http://teaching.berkeley.edu/
10	University of Chicago United States	Engineering Makerspace (http://coemakerspace.uic.edu/) UIC Innovation Center (http://innovationcenter.uic.edu/wordpress/?page_id=475)
12	Yale University United States	Center for the Integration of Research, Teaching, and Learning (CIRTL) (network) (https://www.cirtl.net/) Center for Engineering Innovation and Design (CEID) (http://ceid.yale.edu/about-1/#courses)
13	University of Pennsylvania United States	Leonhard Center for Enhancement of Engineering Education http://www.engr.psu.edu/leonhardcenter/

Rank	Higher Education Institution	Education support
14	University of California, Los Angeles United States	Human resources - Training and Development https://www.chr.ucla.edu/training-and-development
15	University College London United Kingdom	UCL Centre for Engineering Education http://www.engineering.ucl.ac.uk/centre-for-engineering-education/
16	Columbia University United States	Center for the Integration of Research, Teaching, and Learning (CIRTL) (network) https://www.cirtl.net/
17	Johns Hopkins University United States	Center for Educational Resources (CER) http://cer.jhu.edu/about
18	Duke University United States	Human resources https://hr.duke.edu/training/course-offerings
19	Cornell University United States	James McCormick Family Engineering Teaching Excellence Institute (METEI) (https://www.engineering.cornell.edu/academics/teaching/teaching_excellence/) Center for Teaching Excellence (CTE) (https://www.cte.cornell.edu/about/index.html)
20	Northwestern University United States	Northwestern Center for Engineering Education Research (NCEER) http://www.mccormick.northwestern.edu/research/engineering-education-research-center/
21	University of Michigan United States	Center for Research on Learning and Teaching in Engineering (CRLT-Engin) https://crlte.engin.umich.edu/
22	University of Toronto Canada	Education Technology Office (ETO) (http://edtech.engineering.utoronto.ca/) Centre for Teaching Support & Innovation (CTSI) (http://teaching.utoronto.ca/)
23	Carnegie Mellon University United States	Center for Faculty Success (CFS) https://engineering.cmu.edu/faculty-staff/professional-development/center-faculty-success/index.html
24	National University of Singapore Singapore	Centre for Development of Teaching and Learning (CDTL) http://www.cdtl.nus.edu.sg/welcome-to-cdtl.htm
25	London School of Economics and Political Science United Kingdom	Academic and Professional Development Division (https://info.lse.ac.uk/Staff/Divisions/Academic-and-Professional-Development-Division) Teaching and Learning Centre (https://info.lse.ac.uk/Staff/Divisions/Teaching-and-Learning-Centre/Teaching-and-Learning-Centre)

4 Concluding remarks

The importance of education in engineering HEI can be considered indisputable. Nevertheless, the real meaning of this importance is another question. Many engineering HEI consider the “teaching” (education) role of their staff much less important than the “research” role. This relative importance could be analysed in several different ways, namely by staff assessment procedures and criteria, hiring or career development processes, or organizational culture. In this paper the authors analysed data that show one perspective about the importance that some of the most renowned HEI give to the education role. This analysis was made with two angles, one centred in the existence of units that give support to the teaching activities and other that analysed the research that is being made by the HEI staff that is explicitly related to Engineering Education. This analysis is pragmatic in the sense that shows the “energy” that some of the most renowned HEI and their staff put in these activities.

It was possible to identify that all Times Top 25 HEI have units dedicated to engineering education or staff development. Some of these units explicitly refer research in “Engineering Education” (EER) as being part of their mission or activities. Part of these Times Top 25 HEI were also identified in the analysis of the institutions with more journal papers published with the topic “Engineering Education”. In future work, regional analysis could give a more worldwide perspective of these type of units, avoiding to present a larger amount of units from specific parts of the world.

The authors support the idea that both approaches, organizational units that give support to Engineering Education practice and Engineering Education Research, are important for improvement of Engineering Education. This idea is supported by the fact that most of the highly recognized engineering HEI show results on these two paths. Thus, one can consider that these can be seen as interconnected paths with intertwining results. Improving the practice of Engineering Education, also improve the training of new engineers and hopefully reduce the gap between education and professional activity. To attain this improvement, engineering teachers must be close to engineering practice. Being close to the engineering practice creates opportunities to improve research about the engineering practice. In order to continuously improve Engineering Education practice, engineering teachers should be involved in scholarly research about their own practice. In conclusion, a virtuous cycle of education, practice and research, simultaneously about engineering and Engineering Education can contribute significantly to the improvement of engineering schools.

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A Social Network as an Active Learning Environment

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Abstract

This paper reports for the first time the results of using a social network specially developed for the education (Cuboz platform). The tools available on the platform are briefly reported. Basically, lecture videos, lists of exercises, chapters of textbook, and the instructions for the students were weekly posted on the platform. Several professors, many mentoring students, and some technicians are added together with students in the social network. This increases the number of more capable partners available in the platform. The students should follow the instructions, which includes watching the lecture videos, reading some parts of the textbook, and post some lists of exercises periodically. An individual written exam was applied. The grade performances of the students on the written exam were related to the time expended and the activities done in the social network platform. Preliminary results show that the students obtain better grading performances when they expend more time watching the posted videos and practicing with the lists of exercises.

Keywords: Cuboz Platform, Social Network, Active Learning Environment, Long-Distance Social-Constructivism

1 Introduction

In the 1980´s, Seymour Papert predicted that the society would pass through a crisis in the education due to the invention of the computer and its development. He mentioned that

> *There won't be schools in the future … I think the computer will blow up the school. That is, the school defined as something where there are classes, teachers running exams, people structured in groups by age, following a curriculum–all of that. The whole system is based on a set of structural concepts that are incompatible with the presence of the computer.* (Willis, 2003*).*

In fact, nowadays there is a huge controversy in Schools, Colleges, and Universities about whether or not computers and World Wide Web could improve students learning. The discussion has started decades ago mainly in the Institutions that created semipresential and long-distance learning programs supported by the fast development of the Information and Communication Technologies (ICT). There are many successful cases, but it is known that there are several failure examples too. The advantages and problems of these type of programs are still under evaluation up to now in many places all over the world.

Furthermore, many educators understand that the introduction of electronic communication devices could be a problem for the education of young children, especially in very early years. This is matter of controversy once some authors recommend to avoid that because they believe the use of electronic devices has to do with economical and consumption aspects, although others defend the process because it is a natural process, since young children are already immersed in a world full of ICT devices. On the other hand, regarding the education of actual teenagers and young adult students, there are many educators that believe students are already set up with all the skills for using electronic devices and internet in favor of their own learning. This has to do with their growing up at the same time there was the adventure of the fast and large-scale production of the handheld computers, as notebooks, tablets, and smartphones, as well as the development of good quality and easy internet access. Due to that, some researchers believe that society is almost with all the conditions for the "mega-change" predicted by Papert (Martinez & Stager, 2014). This probably will set up a new paradigm in education, which is in agreement with the ideas by Thomas Khun (1970).

In the case of the "mega-change" happens teachers and professors should keep in mind that there would be no big change in their role. Educators should continue finding ways to guide students to learn specific contents in meaningful form (Ausubel, 1973) as fast and as easy as possible. It is well known that students complain for better lectures and using new tools since long ago. It seems that students will bring more and more electronic devices to the classroom. They use these devices not only for chats but also for watching videos and reading textbooks available on the internet to help them to learn almost any content, anytime, anywhere. Therefore, avoiding students to use new ICT seems to be a mistake since it is a natural process for the actual teenagers and young adults.

These aspects remind us that educators must be aware about their responsibility on the motivation (Reeve, 2009), autonomy and commitment of the students, such as described by Freire (1998). On the other hand, this also reminds that educators are the most capable partner established in the Zone of Proximal Development (ZPD) idea developed by Vygotsky (1978). Thus, educators must be updated to the ICT development to be helpful to the students' needs as well as open minded to use all sorts of electronic devices during teaching.

Furthermore, beyond face-to-face conversation during classes described by the social-constructivist learning theory, the handheld devices seem to tune a new form of interaction between peer of students, so-called *long-distance social-constructivism* (De Lima & dos Santos, 2014), which is noiseless in the classroom and can continue even after the classes on virtual interaction way. Additionally to the social constructivist interaction between students, some authors have addressed the interaction between adults (Grossman, P., Wineburg, S., & Woolworth, S., 2001). This has been treated as an interdisciplinary (Fazenda, 2008), collaborative learning (Su *et al*. 2010; Zheng, 2017), in which peers challenge each other improving their own learning on a specific subject or getting success in a particular project.

Along with the ICT evolution, there was another important development, the improvement and dissemination of the Active Learning Methodologies (ALM). There is a huge number of publications discussing about the benefits of the active learning on the Education. The widely used methodologies are the Project Based-Learning, Problem Based-Learning and Peer Instruction. Differently from the traditional teaching and learning process, in which educator is the center of knowledge in the classes, the ALM are focused on the students. These methodologies develop not only the hard contents of a subject but also the soft skill such as communication, teamwork, leadership, and others, attending the three interdisciplinary dimensions, *i. e. to know*, *to make*, and *to be* (Fazenda, 2008).

One of the problems that makes some educators to stay away from the use of ALM is the influence of the peers on the grading performance of a particular student. This is due to the fact that is not easy to grade a specific student on learning a subject (knowledge learning) without the influence of the peers working together. There are several types of methods for measuring knowledge learning, including conceptual map, such as pointed out by Zheng (2017), but it is clear that the problem on measuring performance will be around for some time. On the other hand, additionally there is a pressure by actual students over the educators to adopt ALM in all courses. Due to the problem with grading, using ALM must be made with caution, especially by non-experienced teachers and professors, or in introductory courses in which educators should be sure about the knowledge learning of each particular student.

In the University of São Paulo at Lorena (EEL-USP), several faculty members have given great attention in introducing ALM in many courses of the Engineering undergraduate programs and of the Science Teaching Projects graduate program. The most important methodologies used are Project Based-Learning (Pereira, Barreto, Pazeti, 2017), Peer Instruction (de Lima & dos Santos, 2016), and a new one based upon the face expression of the students (Barreto, 2017). In addition, a special classroom for applying ALM has been used during the last semesters. After approximately 5 years of experience, the results have shown that using ALM improve the learning of the students especially in the professional part of the Engineering programs.

Furthermore, some of the faculty members are still trying to deal with the problem of the performance of a particular student using ALM in groups, especially in the basic courses of the undergraduate programs, such as physics and calculus. In a previous work (de Lima & dos Santos 2016), attention was done to the use of Peer Instruction methodology along with electronic devices and internet access during the introductory courses of

Physics (mechanics contents). This was supported by Facebook, WhatsApp, and Google Forms homepages and smartphone applications.

In order to extend the previous work, in this paper we report the first results of the experience in using a new social network, labeled Cuboz (www.cuboz.com), specially developed for the education, in an introductory course of Physics (electricity and magnetism contents) of the EEL-USP. The performance of the students in an individual written exam are discussed and related to the time expended in watching posted videos and the number of uploaded list of exercises on the Cuboz platform.

2 Methodology

2.1 Social network active learning environment

The social network used in this work is related to Cuboz platform devoted to education. It is primarily intended to make students to interact and collaborate each other in a social network platform, which joins different skills of the other social network platforms such as Facebook and WhatsApp in only one place. Educators can post videos, e-books, lists of exercises, and other additional materials and comments relevant for the course.

The posted videos on the platform for the Physics III course were freeware videos found on YouTube (www.youtube.com). The main video lectures were found in the Khan Academy (www.khanacademy.org). After choosing the video lectures, the textbook, and the lists of exercises, they were uploaded on the Cuboz platform separated into individual classes. The instructions of the work to be done by students were posted once a week, following the same sequence expected for the traditional Physics III course in the EEL-USP.

In this particular work, students should watch the videos, read some parts of the textbook, and post the lists of exercises solved by their own hand in days previously defined. Furthermore, besides adding the students, several professors, many mentoring students, and some technicians related to the area were added to the social network. The main difference regarding the traditional Virtual Learning Environments is the creation of a social network that promotes the long distance social interactionism (de Lima & dos Santos, 2016). The fundamental idea for using a social network is based upon the ZPD idea (Vygotysky, 1978), in which instead having only one or two more capable partners, the social network allows one to add many of them at same time.

2.2 Group of students and data analysis

Initially, there were 128 students enrolled in the course based upon their own choices and requirement criteria. Only after two weeks there was a dropped to 78 students due to the USP programs enrollment criteria.

The class was composed only by students enrolled in Engineering programs of the EEL-USP, such as shown in Table 1.

Table 10. Number of students enrolled in the Physics III class per Engineering Program.

Program	Number of students
Biochemistry	9
Chemistry	10
Environmental	11
Industrial Chemistry	2
Industrial (Production)	39
Materials	4
Physics	3
TOTAL	78

The students should upload the lists of exercises, written by their own hands, approximately every two weeks. This should be done after reading the textbook of the course and watching the lecture videos available on the Cuboz platform.

Such as the course is under way, students should perfume the following set of activities on the Cuboz platform: *a*) watch 270 min of lecture videos with contents related to the basic concepts of the course, *b*) read some chapters of the textbook, and *c*) upload lists of exercises periodically in predefined days. In the case of the videos, it was considered overcame by the students if they expend at least 90% of the expected time watching the videos (small portions of the videos are considered not important for the subject). Cuboz platform allowed us to track the time expended for each student watching the videos.

Some presential meetings were carried out every week only for discussing of some questions and doubts of the students in a type of flipped classroom. After 8 weeks, students carried out an individual written exam, labeled Exam 1 (E1).

The collected data of this work include: *i*) the time for watching videos and *ii*) the upload of the lists of exercises on the Cuboz platform, and *iii*) the scholar curriculum of each student, which reports the School Performance Coefficient (SPC), the Average Performance Coefficient (APC) of their own program, and possible previous course fail. The possible influence of the enrollment year of each student was also investigated. The whole set of data was quantitatively related to the grading performances of the students obtained in E1.

For this particular work, we used the data available up to now, which is related to the first half of the Physics III course ran by one of the authors.

3 Preliminary results

The preliminary analyses of the scholar curricula allowed to observe that 20 students are in phase with their program, 29 have School Performance Coefficient equal or above the highest Average Performance Coefficient of the programs (APC ~ 6.5), and 14 students did not fail any time in their courses (all of them also have SPC ≥ APC).

Table 2 shows the number of students that obtained different grades in the individual written E1.

Table 2. Average grades.

Grade	Number of students	Average grade
≥ 5.0	20	6.1 ± 1.1
Between 3.0 and 4.9	23	4.2 ± 0.5
< 3.0	35	1.2 ± 0.9

TOTAL	78

If the E1 would be the final grade, approximately 26% of the students would get grade to pass the course, 45% would fail, and the rest (~ 29%) should apply for a new exam. We have noted that the 20 students that obtained grade ≥ 5.0 were those who expend more time watching the videos and/or submitted more list of exercises (75% or more).

In Table 3 and Figure 1 are reported the number of students and their grading performances related to the submission percentage of the lists of exercises.

Table 3. Submitted lists of exercises.

% of submission	Grade average	Number of students	Grade ≥ 5.0	Grade ≥ 3.0 and < 5.0	Grade < 3.0
100	4.2 ± 1.6	22	8	8	6
75	3.7 ± 1.6	24	7	10	7
50	3.4 ± 2.3	10	4	1	5
25	2.4 ± 2.0	7	1	2	4
Zero	1.2 ± 1.1	15	0	2	13
TOTAL		78	20	23	35

There is a clear correlation between the number of students that submitted the lists of exercises and their grade. The more students sent the lists of exercises the higher the grades are. Additionally, one can see that ~ 37% of the students (13 of 35) that obtained the lowest grades submitted none list of exercises. On the other hand, the majority of the students that obtained grades above 3.0 (33 of 43 ~78%) submitted more than 75% of the lists. In our opinion, this could be related to the time expended by each student reading the textbook and exercising.

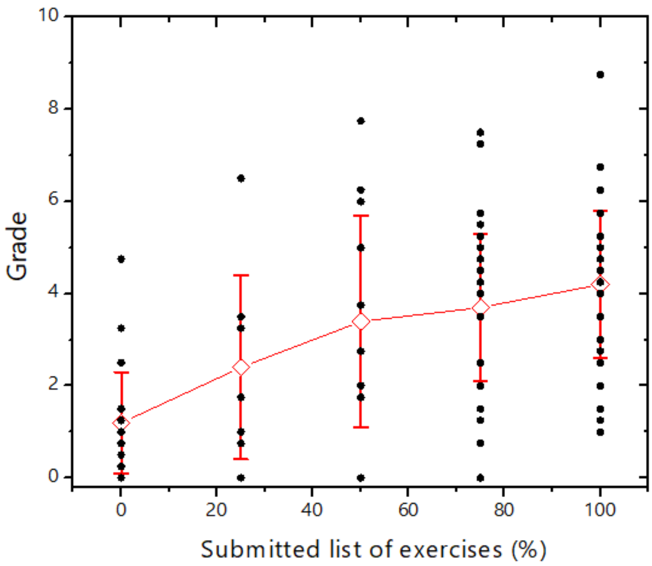

Figure 20. Individual (black symbols) and average grades (red symbols) for the 78 students enrolled in the Physics III course. The number of individual grades appearing in the figure is lower than 78 due to some overlapping. Red line is a guide by the eyes, which connects the average grades.

Additionally, Figure 1 shows unambiguously that the performance of the students (individual and average grades) is dependent on the number of submissions. This can better seen by the red line, which connects the average grades.

The black symbols in Figure I represent the individual grades of the students. One can observe that most of the data fall into the error bar, however there are exceptions, such as: *i*) some students that sent the lists of exercises and obtained zero grades in E1 and *ii*) there are students that obtained good grades without making any submission. These exceptions will be discussed in near future.

Table 4 shows the numbers of students who expend different time watching the posted videos on the Cuboz platform.

Table 4. Number of students that watched videos.

% Videos watched	Number of students
≥ 100 %	33
Between 90 and 100%	11
< 90%	34
TOTAL	78

More than 56% of the students (44) expended more than the expected time for watching the videos.

Some data relating better and worse grades to the time of watching the videos are reported in the Table 5.

Table 5. Dependence of the average time of watching the videos (expected = 270 min) with grading performance in E1.

Grade / % Watched	Number of students	Grade average	Average time of watching videos (min)
≥ 5.0 / > 90 %	12	6.2 ± 1.2	380 ± 130
< 3.0 / < 90 %	18	0.9 ± 0.7	100 ± 80

From the 20 students that have obtained better grades (see Table II), 12 of them (60 %) were those who expended 90% or more of the time watching the videos and submitted at least 75% of the lists of exercises.

Regarding students that obtained grades lower than 3.0, ~ 51% students (18) expend only 1/3 of the time expected for watching the videos, despite the fact they submitted the lists of exercises or not.

Finally, preliminary results suggest the enrollment year do not have any effect on the students' grading performance. Furthermore, the influence of the previous student's performance coefficient, the enrollment in a particular program, the interaction of the students on the Cuboz platform, and novelty of the use of a social network on the individual and average grades are still under investigation. The results will be reported soon.

4 Conclusion

Considering there were no traditional classes during the half time of the course, only meeting for discussion to solve questions and doubts of the students, we can stress out that Cuboz platform has been good enough to provide a new medium for teaching and learning in active way.

The preliminary results show that students obtain better grading performances when they expend more time watching the posted videos and/or practicing with the lists of exercises.

This first experience reported here shows that Cuboz platform allows the students to learn the basic contents of the course in a more autonomy way, within a type of blended learning.

The interaction between students on the platform is still under investigation and will be reported in near future.

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How do teachers reflect upon their teaching in teaching portfolios? – Analysis of teachers´ portfolios at seminars on how to document your pedagogical qualifications and skills at the Chalmers University of Technology

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Abstract

The Chalmers University of Technology has for many years stressed the importance of pedagogical qualifications and skills. In the Chalmers´ Faculty Appointment Regulations and in Chalmers vision of pedagogical competence (Chalmers´ vision of pedagogical competence, 2017) it is decided about the requirements for how the pedagogical competencies and skills should be documented.

International development of pedagogical skill has been highlighted for more than 30 years (Report to the European Commission on Improving the quality of teaching and learning in Europe's higher education institutions, 2013; Gunn, V. & Fisk, A., 2014).

The Scholarship of Teaching and Learning (Antman, L. & Olsson, T. 2007; Boyer, 1990; Kreber, C. , 2006; Trigwell, K., Martin, E., Benjamin, J. & Prosser, M., 2000; Trigwell, K. & Shales, S. , 2004) is a concept used in the development work at the Chalmers University of Technology and also implemented in all courses in teaching and learning in higher education for employed teachers.

The Chalmers University of Technology has developed guidelines for writing the teaching portfolio (Chalmers University of Technology. *Guidelines for pedagogical portfolio,* 2017). In the teaching portfolio, teachers' are encouraged to document their pedagogical practices and experiences and to reflect upon concrete examples of their teaching using the didactic questions; *what, how, why,* and *the result* of their teaching and student learning. To show pedagogical skill, the teachers' reflection is a very important part of the teaching portfolio. This paper reports and discusses qualitative aspects regarding how teachers reflect and write about their teaching practice and student learning.

The study indicates that teachers have difficulties to reflect critically upon their teaching and supervision. The texts are often more descriptive and quantitative than reflective. It is frequently unclear how teachers' proven experience and teaching approach/theory are applied in the teachers' pedagogical practice in order to support student learning. In addition, the teachers' development perspective, i.e. future vision, is often lacking; how do I work with pedagogical tasks today and how do I want to develop my pedagogical competence in the future? This has consequences for how teachers work with educational development and for how, for example, active learning is implemented.

Keywords: Academic development; competence development; Scholarship of Teaching and Learning (SoTL); pedagogical skill; pedagogical gualification; educational development; active Learning; engineering education.

1 Introduction

International development of pedagogical skill has been highlighted for more than 30 years (Report to the European Commission on Improving the quality of teaching and learning in Europe's higher education institutions, 2013; Gunn, V. & Fisk, A., 2014).

In higher education there is an increased focus on the quality of teaching and learning and thus on pedagogical competence and pedagogical skills.

At Chalmers, and also at many other universities in Sweden, work has been going on for many years to support and pay attention to teachers' educational assignments and their skill to perform them.

The Scholarship of Teaching and Learning (Antman, L. & Olsson, T. 2007; Boyer, 1990; Kreber, C. , 2006; Trigwell, K., Martin, E., Benjamin, J. & Prosser, M., 2000; Trigwell, K. & Shales, S. , 2004) is a concept used in the development work at the Chalmers University of Technology and also implemented in all courses in teaching and learning in higher education for employed teachers. During these courses, teachers work with pedagogical projects and write papers, which can be used as examples to show teaching practice and pedagogical skill in their teaching portfolios.

The Chalmers University of Technology has in Chalmers´ Faculty Appointment Regulations, in Chalmers vision of pedagogical competence (Chalmers´ vision of pedagogical competence, 2017) stressed the importance of pedagogical qualifications and skills and decided about the requirements for how they should be documented. There are several activities going on at Chalmers in order to emphasize the importance of pedagogical skill.

The Chalmers University of Technology has developed guidelines for writing the teaching portfolio (Chalmers University of Technology. *Guidelines for pedagogical portfolio,* 2017*)*. In the teaching portfolio, teachers' are encouraged to document their pedagogical practices and experiences and to reflect upon concrete examples of their teaching using the didactic questions; *what, how, why,* and *the result* of their teaching and student learning. To show pedagogical skill, the teachers' reflection is a very important part of the teaching portfolio.

This paper reports and discusses qualitative aspects regarding how teachers reflect and write about their teaching and student learning. The aim of this study is to highlight aspects of quality in teaching portfolios.

2 Chalmers guidelines for writing a teaching portfolio

The Chalmers guidelines for writing a teaching portfolio (Chalmers University of Technology. *Guidelines for pedagogical portfolio,* 2017) ask the teachers to follow a template with the following 10 subheadings:

1 Background and brief presentation
2 Education
3 Experience of teaching and supervision
4 Your pedagogical activities: approach, reflection and development
5 Production of study materials
6 Management in the field of education
7 Scholarship of Teaching and Learning
8 Pedagogical activities and knowledge sharing outside the university world
9 Other pedagogical qualifications and
10 Appendices - boxes with material supporting the 9 headings above.

Below each heading there is a text describing what teachers´ are expected to include in the text.

The focus in this paper is on the fourth heading "Your pedagogic activities – description, reflection and development". The clarifying text to the teachers regarding the fourth subheading is:

This section is one of the most important parts of the pedagogical portfolio. Describe your basic pedagogical outlook; that is, describe your approach to teaching, supervision and student learning that forms the basis for your pedagogical work. By describing and reflecting on your pedagogical activities and conditions for learning, clarify your approach to current and future pedagogical assignments.

Under a-c below, select a few examples from your pedagogical activities to exemplify your pedagogical competence. For each example, carefully:

· *Describe and reflect on what you have done, how you have worked and justify why you chose that way of working, what has gone well and what could be improved, how your way of working promotes student learning and what the results of your pedagogical work have been.*

· *Describe and reflect on how your pedagogical activities are based on proven experience and how they relate to theory, development and research in higher education.*
· *Describe your future goals and visions and your views upon future pedagogical work and continued skills development.*

a) Select 1-2 courses from your pedagogical activities and show how you work as a teacher.
Your course examples might include how you have planned, implemented, evaluated and developed a course, course element, laboratory experiment or exam.
b) Select 1-2 supervision assignments to demonstrate how you work as a supervisor.
c) Select 1-2 examples that demonstrate how you act as responsible for other higher education assignments.
This might cover pedagogical development projects, for example, or assignments as e.g., vice head of department, teacher team leader, head of programme, or dean of education.

Materials such as course descriptions, lecture plans, exam tasks, laboratory experiments, reports on pedagogical development work or other materials that you have developed should be attached as appendices.

3 Seminar series writing a teaching portfolio

The Chalmers University of Technology and the University of Gothenburg offer in cooperation from autumn 2017 a seminar series on how to write a teaching portfolio. It is a guiding resource for teachers at both universities aiming at facilitating for teachers who intend to write their teaching portfolio. The series consists of three seminars. The teachers have to make separate applications to these three seminars. All participants must prepare for the seminars.
Before the first seminar, the participants are required to do preparatory studies and read recommended literature and study the Universities vision resources regarding pedagogical skills.
Before the second seminar the participants are required to read each other reflection texts (the fourth subheading) in order be able to give feedback and discuss at the second seminar.
Before the third seminar the participants continue to develop and write the remaining parts of their teaching portfolios in order to make it as complete as possible before the third seminar. T**he entire third seminar will be devoted to feedback on and discussion of the participants' teaching portfolios.**
The participants are divided into groups prior to the third seminar. Everyone should prepare by reading all of the portfolios in a group and one week before the seminar every participant will be allocated one portfolio to critically review and prepare to give useful feedback during the seminar. The participants are asked to use the assessment criteria for teaching portfolio at Chalmers for the review.

> In earlier years from 2012 Chalmers (and also the University of Gothenburg) offered shorter seminar series for writing a teaching portfolio. However, both universities have realized – judged from portfolio texts handed in and from the participants' oral statements - that it is not enough to offer only two seminars.

The seminar series for teachers preparing their teaching portfolio provides strong guidance about what a portfolio should contain. The text, the reflection in the teaching portfolio should closely be integrated with examples from the teachers´ teaching practice.

4 Method

In this study we have focused on the teachers' reflection texts i.e. the fourth heading "*Your pedagogic activities – description, reflection and development*" in the Chalmers guidelines for writing a teaching portfolio (Chalmers University of Technology. *Guidelines for pedagogical portfolio*, 2017*)*.
The reflection texts about the teachers own chosen concrete examples of teaching/supervision are handed in before the seminar in a web discussion forum and are then discussed at the seminar.

The teaching portfolios (the fourth heading) were investigated with the aim to highlight aspects of quality in teaching portfolios regarding pedagogical competence and pedagogical skills.

Thus, in this study we have analyzed 20 teachers' reflection texts i.e. the fourth heading "*Your pedagogic activities – description, reflection and development*" using the didactic questions: What? How? Why? and What results?

- What is taught?
- How is the subject taught?
- Why is the subject taught in that way? - motivation, reflection and references to educational literature
- What results have been achieved? What are the results/effects of the teachers´ pedagogical choices/actions on student learning?

5 Analysis

Analysis of teachers´ portfolios - the teachers' reflection texts i.e. the fourth heading "*Your pedagogic activities – description, reflection and development*"- at the seminar series on how to document your pedagogical qualifications and skills at the Chalmers University of Technology has been carried out. As described the didactic questions - What? How? Why? and What results have been achieved? – have been used in the analysis.

The teachers' reflection texts are usually 2-4 pages long and contain examples from the teachers practice. Analysis of the reviewed teachers´ texts in the fourth heading of the Chalmers guidelines for writing a teaching portfolio "*Your pedagogic activities – description, reflection and development*" shows that it is a challenge to teachers to reflect on one´s own teaching and student learning. This is indicated by the following:

- The texts are often more descriptive and quantitative than reflective
- The relation between the teachers´ teaching approach, educational theory and how it is applied in the teaching practice to support student learning is often unclear
- Teachers´ development perspective is often lacking
- The students and student learning are sometimes absent, not mentioned at all, in the teachers´ reflection texts
- How educational research and educational theories are treated – if the text only in a general way is related to literature or if particularly relevant educational literature is referred to explaining the teachers´ pedagogical choices and strategies for student learning

Thus, despite the clarifying text to the fourth subheading "Your pedagogic activities – description, reflection and development" the teachers still have problems writing the text for this section and in a reflective way write about and show their pedagogical skills.

So, this study indicates that teachers have difficulties to reflect critically upon their teaching and supervision. The texts are often more descriptive and quantitative than reflective. It is frequently unclear how teachers' proven experience and teaching approach/theory are applied in the teachers' pedagogical practice in order to support student learning.

In addition, the teachers' development perspective, i.e. future vision, is often lacking; how do I work with pedagogical tasks today and how do I want to develop my pedagogical competence in the future?

From the seminar series meetings and discussions about the participating teachers´ reflection texts (the fourth heading) it is obvious that the teachers are not used to and not comfortable with writing a personal reflection regarding their teaching and supervision. This is not very surprising as this type of text differs a lot from what they write in their research subject. Yet still, from the seminar series you can often in the discussions see an engagement of working with teaching and learning issues and a clear interest to support student learning.

The findings in this study are likely to have consequences for how teachers work with educational development, for example how active learning is implemented and used in teaching to support student learning.

6 Discussion

With the results from this study we find it important to continue to study how teachers write and reflect about their teaching practice and how it changes over time.

Chalmers encourage teachers to take a scholarly approach and the Scholarship of teaching and learning, SoTL concept is used in development work and in the higher education courses to employed teachers. Teachers are encouraged to engage in their teaching practice in an academic manner (Trigwell, K., Martin, E., Benjamin, J. & Prosser, M., 2000). The aim is to provide conditions for building a continuing SoTL process at the university.

Chalmers regard a scholarly teacher as an individual who is able to relate his or her own practice to theories of teaching and learning.

To follow the SoTL concept and being a scholarly teacher also means making one´s practice public by sharing it in various academic contexts. Arguing, sharing and dissemination is a crucial aspect of any scholarly work. This provides possibilities for critique and exchange of pedaqogical ideas and interaction that can influence the teachers teaching practice and student learning.

Teaching practice and student learning can be made visible and transparent by sharing at conferences and publications in educational scientific journals. However also at the departemental level it is important to create good opportunities for communication and dialogue about pedagogical, higher education issues.

According to the SoTL concept the teacher should use own experiences in combination with literature in the teaching and learning field in order to reflect on their own teaching and learning practice and use this knowledge for further pedagogical development.

Theoretical competence in pedagogy for higher education and pedagogical content knowledge are of importance for the teacher´s perspective on teaching and student learning. Studies of learning theories start reflection which can affect the teachers own practice. Learning theories from others may confirm the teachers own teaching practice. The teachers´ philosophy of teaching and learning may deepen or even change.

Higher education courses is offered to teachers at Chalmers and for promotion it is necessary to have studied at least ten weeks of higher education courses or to have corresponding courses and/or experiences which have been validated.

There is also a yearly hold conference at Chalmers local campus conference where all Chalmers teachers have the possibility to send in contributions and share with their colleagues in order to build knowledge within the higher education subject. The aim of the conference is to inspire scholarly discussions about teaching and learning, to give teachers an opportunity to document pedagogical experiences and to take part of their colleagues documented and reviewed examples of teaching and learning practices. For example, a great interest for flipped class room was clearly mirrored at the 2017 conference and sharing of experiences among teachers.

In addition to these activities offered to teachers at Chalmers seminars for writing a teaching portfolio is arranged. Chalmers regards the writing of a teaching portfolio as an important part of building the SoTL concept within the university.

Thus, at Chalmers several arenas are available for sharing and disseminating scholarly reflections of teaching practice and student learning

Associated to these activities/arenas Chalmers teachers are encouraged to investigate the relationship between their own teaching and student learning. This involves planning, carry out, analyse, reflect upon, document, problematize, regard students course evaluations and decide about and plan for the next course.

The plan for the next course, pedagogical set up should be well motivated and based on the teachers experiences, observations made during the latest course and educational scientific literature and with the use of the didactic questions What? How? Why? and What results?

The question for the future is: What is the relation between good quality in reflective texts regarding teaching and learning, and good quality of the actual teaching practice?

7 Conclusion

Thus in their teaching portfolios teachers´ need to tell about, and with concrete examples from their teaching practice show what they believe is important in teaching and how they act to best support student learning.

The teachers need to show and motivate their pedagogical choices, their planning, their justification of pedagogical approach, their implementation and the results and analysis of their pedagogical work.

Beside the use of a teaching portfolio to show pedagogical skill at promotion or employment, a very important way to use the portfolio is for formative evaluation of the teachers´ own teaching practice and for own pedagogical competence and skill development.

A very interesting question to continue studying is: What is the relation between good quality in reflective texts in teachers´ teaching portfolios and good quality of the teaching practice?

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Experiences and Challenges in Project Based Learned during Product Design Course – Practical Case

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Abstract

One the most important challenges of engineers is to work as a high-performance team, where projects must be developed considering complexed activities, deadlines, financial budgets and high-quality deliverables. In this context, in the last two years, different experiences have been developed in the Product Design Methodology Course applying the Project Based Learning (PBL). This experience was performed in a PBL intituled "Catapult Project". During the project, some metrics were applied to evaluate the group performance, using project management software with critical chain approach and other initiatives. The aim of this work is to present and discuss these practices in PBL that were applied in Graduation Engineering Courses of Federal University of Santa Catarina. To develop this evaluation in the end of semester was applied a form to analyse the course organization and time to develop the project, evaluate the individual performance, the level of difficulty to work in group and the project management experience, as well the acquired knowledge . The results shows that the use of PBL is a good practice to introduce new team work experiences and motivate the students, being the development of soft skills the main challenge for the students during the course .

Keywords: Active Learning; Engineering Education; Symposium Information; Project Approaches.

1. Introduction

The Project-based learning has been introduced in some engineering courses as an appropriate and effective method to teach product design theory, method and tools.

According PMI (PMBOK, 2015) a project is a temporary endeavor undertaken to create a unique product, service or result. A project is temporary in that it has a defined beginning and end in time, and therefore defined scope and resources.And a project is unique in that it is not a routine operation, but a specific set of operations designed to accomplish a singular goal. So a project team often includes people who don't usually work together – sometimes from different organizations and across multiple geographies.

The development of software for an improved business process, the construction of a building or bridge, the relief effort after a natural disaster, the expansion of sales into a new geographic market — all are projects.

And all must be expertly managed to deliver the on-time, on-budget results, learning and integration that organizations need.

In this context, in the last two years, different experiences have been developed in the Product Design Methodology Course applying the Project Based Learning (PBL). This experience was performed with all teams having the same project named "Catapult Project".

During the project, metrics were applied to evaluate the group performance, used a project management software, chances the project deadline and other initiatives. The aim of this paper is to present and discuss these practices in Project Based Learning (PBL) that were applied in Graduation Engineering Courses of Federal University of Santa Catarina.

To develop this evaluation in the end of semester, a form was used to analyze the course organization, to evaluate the individual performance, to analyze the time to develop the project during the semester, the level of difficulty to work in group, the project management experience, as well the knowledge acquired during the semester. The results shows that the use of PBL is a good practice to introduce new team work experiences and motivate the students, being the development of soft skills the main challenge for the students during the course.

2. Project Based Learned

Project-based learning is a very effective approach that allows the students to throw out opinions about the topics covering fields of interest, to ask questions, to estimate, to develop theories, to use different tools, to use the skills acquired in the context of a real and meaningful life and allows learner to solve problems and answer questions in a creative way in the classroom and outside (Katz & Chard, 2000).

Thomas (2000) adopts five criteria to define PBL: 1) "Projects are central, not peripheral to the curriculum"; 2) "projects are focused on questions or problems that 'drive' students to encounter (and struggle with) the central concepts and principals of the discipline"; 3) "projects involve students in a constructive investigation"; 4) "projects are student-driven to some significant degree"; and 5) "projects are realistic, not school-like". Collaboration, as a matter of fact, should also be included as a sixth criterion of PBL (Thomas & Mergendoller, 2000).

Many researches describes the project based learned process. Stoller (2005) summarized in the following ten steps the process to develop a project based learned. The application a PBL in product design course was based in this approach.

- Step 1: Students and instructor agree on a theme for the project.
- Step 2: Students and instructor determine the final outcome.
- Step 3: Students and instructor structure the project.
- Step 4: Instructor prepares students for the language demands of information gathering.
- Step 5: Students gather information.
- Step 6: Instructor prepares students for the language demands of compiling and analyzing data.
- Step 7: Students compile and analyze information.
- Step 8: Instructor prepares students for the language demands of the culminating activity.
- Step 9: Students present final product.
- Step 10: Students evaluate the project.

3. PBL Practice in Project Methodology

8.1 3.1. Product Design Process

The product development process (PDP) can be organized in phases from market research, product design process, manufacturing design process, distribution plan, maintenance plan until the product disposal phase.

Back et al. (2008) present a reference model called the Integrated Product Development Process – PRODIP. This model is organized in macrophases, phases, activities, tasks, inputs, tasks outputs, mechanisms and controls, in order to assist in the understanding and practice the product design process. The model is composed in three macrophases: project planning, product design and process development.

In the project planning macrophase is developed the project plan including the project scope, time,costs, risks, communication, acquisition, human resource and integration. To support this phase can be used tools asWBS (Work Breakdown Structure), Gantt Chart, Matrix of Responsibility and others.

The product design process involves the design specification phase, conceptual, preliminary and detailed design.

In the design specification phase is a process to transform market information into product technical specifications. In this phase can be applied methods and tools such as quiz to identify client's needs, QFD (Quality Function Deployment), TRIZ (Theoy of Inventive Problem Solving) and others.(Akao, 1990) (Ferreira, 2002) (Pahl and Beitz, 2005)

In the conceptual design intend to generate alternative solutions according the specifications defined in the previous phase. In this phase is evaluate and select the best and most innovative design for the product. (Back et al, 2008). The selected product conception represents the product in its main functionalities and principles of solution. This phase is intense in creativity. The propose is generate alternative solutions to increase the chance of success of innovative solutions for the product. In this stage several methods of creativity are used.

In the preliminary design phase the product is optimized. Is defined the layout, some materials, the main dimensions and manufacturing processes. In this phase is evaluate the technical and economic viability of the product. In this phase there is a greater intensity of modeling, simulation, analysis, testing and product optimization activities, where tools such as CAD and CAE systems, model construction and prototypes are applied. (Back et al, 2008)

In detailed design the prototype is approved, all component arespecified, is developed the manufacturing plan.

And, the last macrophaseis implemented the initial batch, which involves the execution of the manufacturing plan in the production of the company and the closing of the project. In this phase occurs the production preparation, product validation and product launch.

This article focuses on the project planning, design specification and conceptual design phase. These phases are taught in the Product Design course using the PBL concept - Project Based Teaching.In the case, the project in question involved the development of a catapult, as described below.

8.2 3.2. Catapult Project

Catapult physics is basically the use of stored energy to hurl a projectile (the payload), without the use of an explosive. The three primary energy storage mechanisms are tension, torsion, and gravity. The catapult has proven to be a very effective weapon during ancient times, capable of inflicting great damage.

Considering the PBL approach, the teams should build a catapult with the following scope:

- Maximum dimensions of the catapult (C x W x H): 500 mm x 500 mm x 500 mm;
- Maximum weight of the catapult: 5 kg;
- Projectile diameter: 100 mm diameter;
- Projectile weight: 200 g;
- The catapult must have a target sight system;
- Only the catapults approved in the test will be able to launch the projectile;
- The launching of the object by the catapult must take using a trigger button.

To manager the project was applied a project manager project, Exepron. Exepron is a change management application with a user-friendly way to Plan, Schedule and Execute a Portfolio of Projects in real-time. Exepronis critical chain project management. This approach was introduced by Dr. Eliyahu M. Goldratt in 1997. Critical Chain Project Management (CCPM) is an innovative method for planning, scheduling, and managing performance in a project environment based on Goldratt's Theory of Constraints (TOC). CCPM differs from traditional project management methods such as "PERT" and "Critical Path" (CPM), which relies on completing tasks in a specific order with inflexible scheduling. CCPM is applied in single-project and multi-project environments (PPM – Project Portfolio Management) where resources are shared across multiple projects.

4. Analysis of the PBL Practices in the discipline of Project Methodology

To perform this analysis, a questionnaire was developed and applied to 48 students from 5th phase of the 10-phases engineering courses.

The questions were organized into three groups: Group 1) Questions about student and course development during the semester; Group 2) Questions about difficulties about the product development process; and Group 3) Questions about the experience in the use of project management software.

In the first group of question the objective was to understand how the different exercises proposed during the course were developed and how these exercises impacted in the academic life considering the assimilation part of the content and in the necessary interpersonal relations between group members.

The first question had the objective to know if the organization of the product development process in the phases, stages and activities contributed to the understanding and execution of the product design. Considering the answers presented in Figure 1, it is possible to perceive that the students considered that this model of organization contribute to understand the product design process.

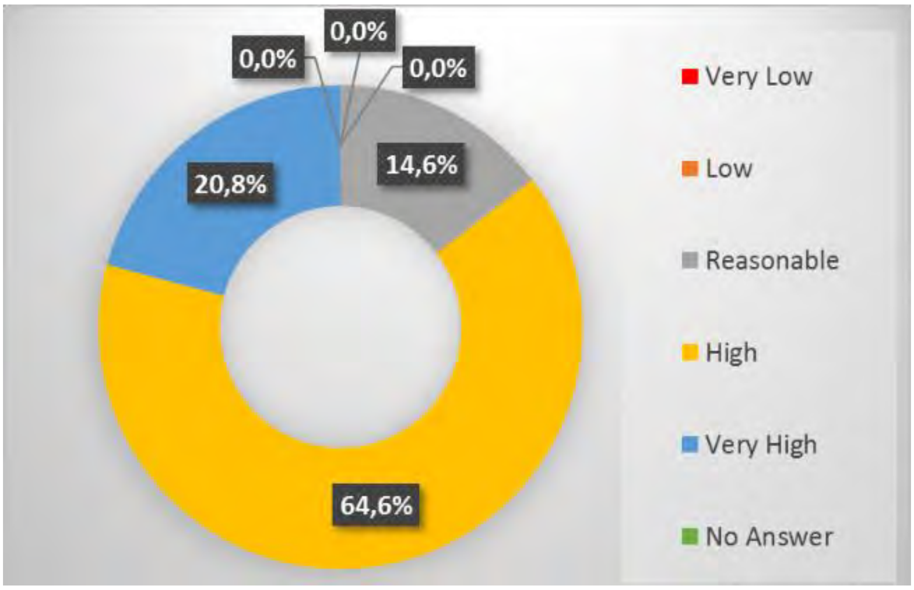

Figure 1. Degree of contribution of the type of organization to the understanding of projects. Source: Authors (2017)

The second question was whether an individual grade should be given to each team members. The grade is related to the individual performance in the group activities.In Figure 2 is presented the answers. The distribution of answers was very similar, with a small advantage of people who believe that there is no need for a grade (52.1%).

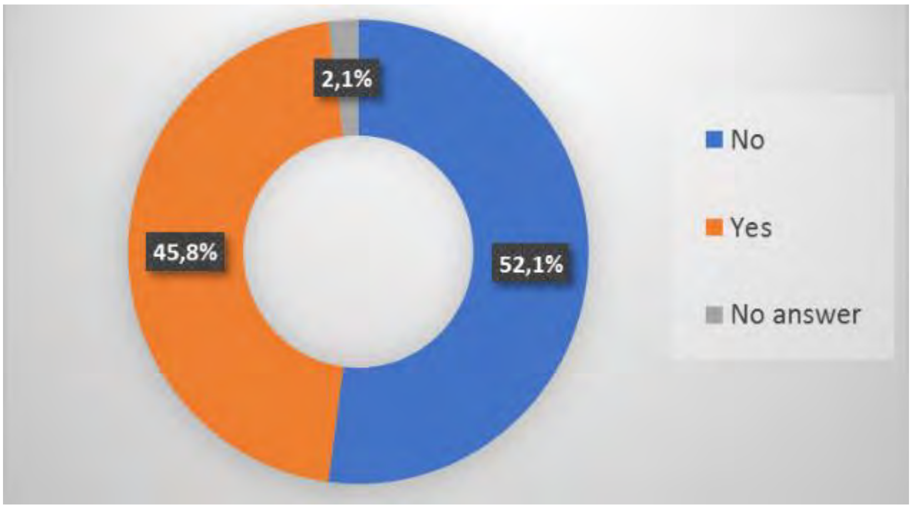

Figure 2. Need for note assignment for students. Source: Authors (2017)

The time needed to organize the project development reports (three in total) was the subject of the third question. The purpose was to know if the time required to develop the project´ reports was adequate. In this case, as presented in Figure 3, 89.6% of students answers that the time is adequate.

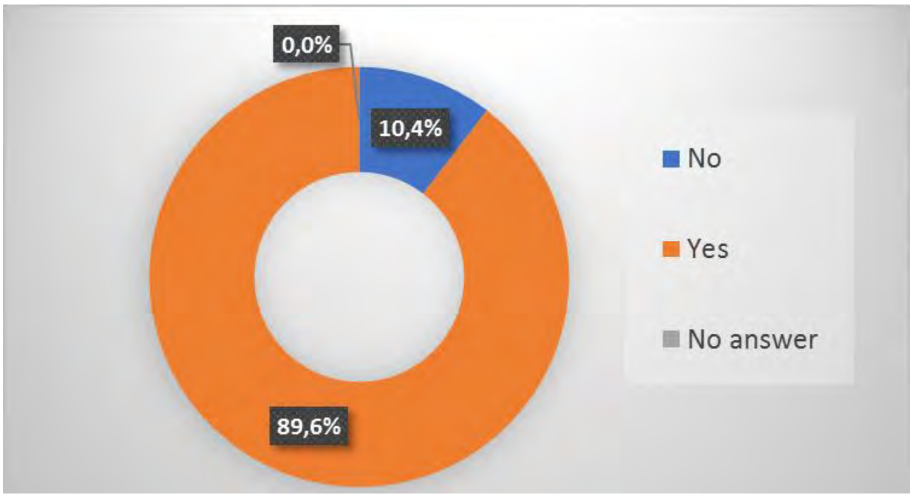

Figure 3. Adequate time for the execution of the proposed works. Source: Authors (2017)

Finally, was asked the degree of gain of knowledge about product development process at the end of the discipline. All possible options were scored, but most students considered a high gain (62.5%) and intermediary gain (35.4 %), as presented in Figure 4.

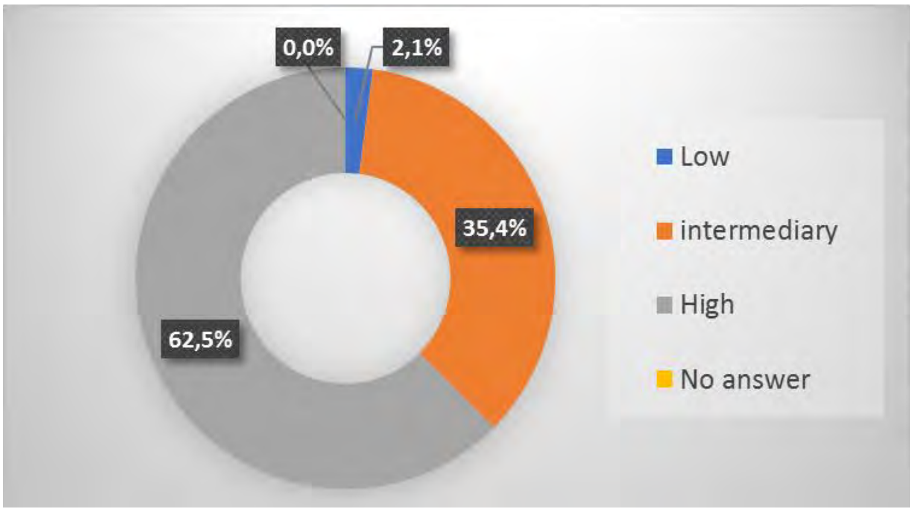

Figure 4. Degree of knowledge acquired. Source: Authors (2017)

In the second group of questions, the questions evaluated difficulties during the product design process. Students answered the following questions:

- Considering the project planning process and the areas of knowledge described in PMBOK (2015), which three areas of knowledge was difficult to plan?
- What level of difficulty did the team have in developing the Project Planning Report, Design Specification Report and Conceptual DesignReports?
- What level of difficulty did you encounter in teamwork?

After collecting answer from students, the following results are presented:

- The 03 (three) area of knowledge considered more complex and difficult to develop were the time plan / schedule (15.3%), the human resources plan (14.6%) and the product and project scope (13.9%). The results are presented in Figure 5.

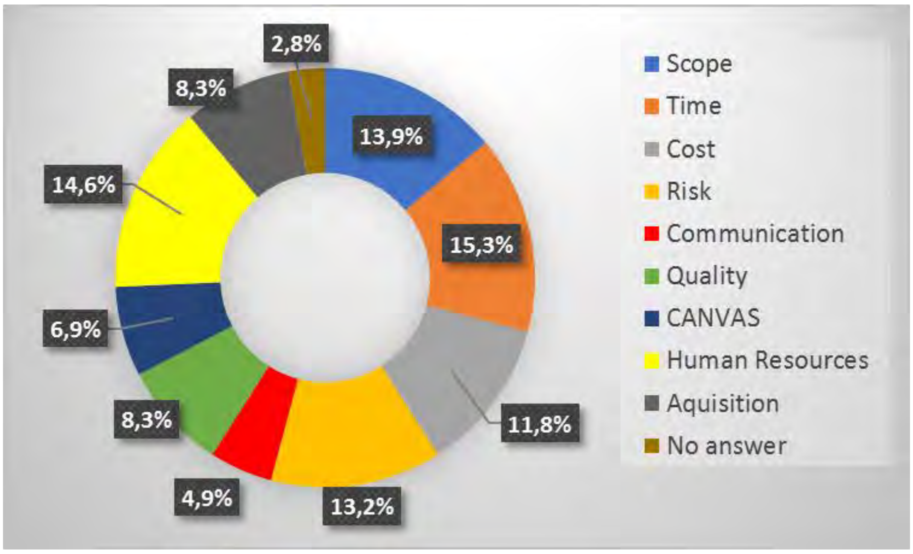

Figure 5. Major difficulties in Project Planning. Source: Authors (2017)

- Considering the student should developed three reposts: project planning report, design specification report and conceptual design reports, in the Table 1, is presented the difficulty level in develop each report.

Table 1. Percentage of students' votes relating the project phases and their difficulty

Project Phase	Level of Difficult				
	Very low	Low	Reasonable	High	Very High
Project Planning	4.2%	35.4%	50.0%	10.4%	0.0%
Design Specification	4.2%	20.8%	41.7%	31.3%	2.1%
Conceptual Design	0.0%	29.2%	50.0%	16.7%	4.2%

- About the difficulty of working as a team was very variable. People who felt very little difficulty were 8.3%, little 41.7%, reasonable 31.3%, high 12.5%, very high 4.2% and only 2.1% did not answer the question. This result is presented in Figure 6.

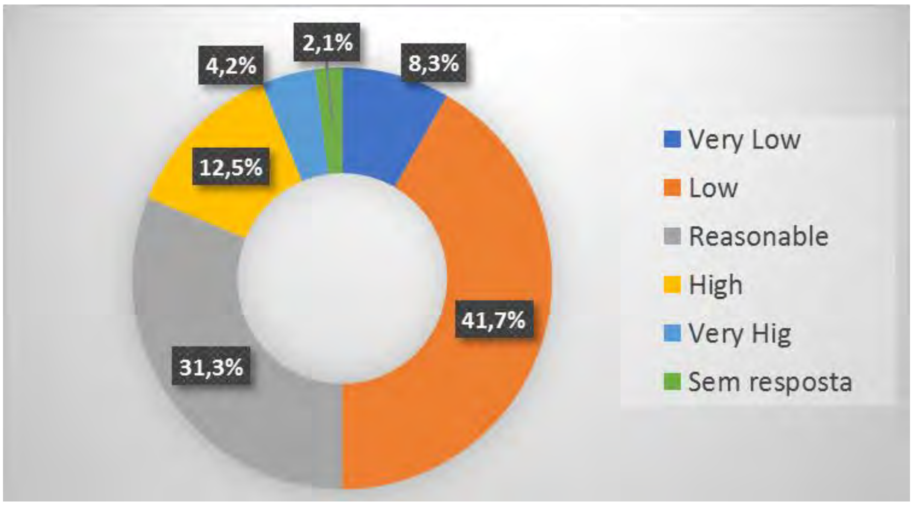

Figure 6. Difficulty of working in group. Source: Authors (2017)

Regarding the experience in using the Project Management Software (Group 3). During the semester a software was used by the students for a better understanding of the discipline. Regarding the use of this teaching method, some questions were also created to better follow the teaching methodology implemented.

It was asked if the person who is responding to the questionnaire was responsible for updating the software in question, showing that 15 people (31.3%) were responsible to actualize the project status in the software. These people had a project manager status.

For the 68.8% who were not responsible for updating the project status in the program, it was asked whether there was a follow-up with their representatives (project manager) of these updates. In this case, 81.8 % accompanied the process and 18.2 % did not.

In the sequence, was developed a survey about the satisfaction in use the software. Only 18.8% of the students stated that the use of the program contributed to the assimilation of the content, while 16.7% stated that there was no contribution.Most people (62.5%) said that it was an experience that contributed only partially to the general understanding.

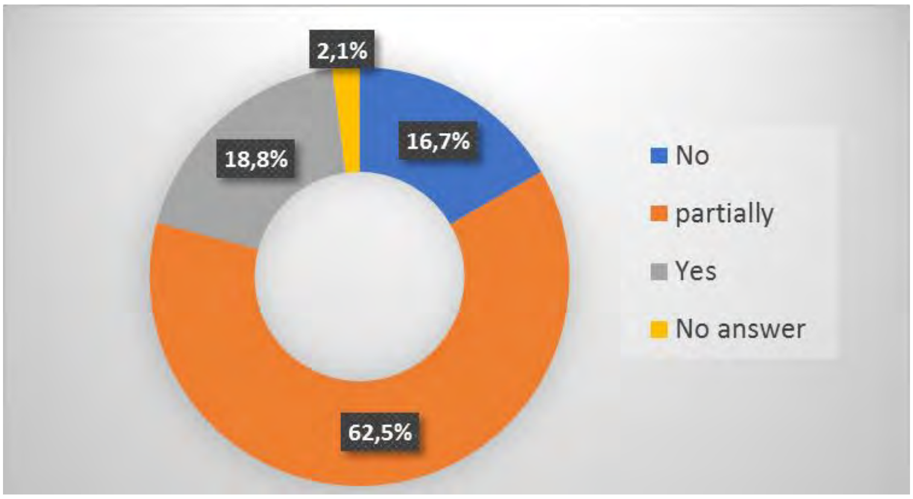

Figure 7. Use of project management software contribution for the course. Source: Authors (2017)

5. Conclusion

The results obtained with the data collection from the students in this research was compared with the results obtained in similar research developed in 2012 and described in Ferreira et al (2012).

The first possible analysis is related to the organization of product development process in the phases, steps, and activities. In Ferreira et al (2012), 91% of students demonstrated that this organization contributed high to the understanding and execution of the project. In the present study, even using different parameters, the percentage of students who found the contribution "High" or "Very High" was only 85.4%. This high number indicates that the practice of PBL is interesting approachto teach product design methodology. On the other hand, the fall that almost 5 percentage points, should be monitored, as it may indicate a saturation of the type of project under development, i.e., catapult project.

In terms of teamwork, in present research 50% of the students said that the difficulty level was "very little" or "little", while in the last study it was shown that only 5% of the students had this same level. Clearly you can see that interpersonal relationships during work have been improved, making people more jointed as a project team and reducing internal conflicts, turning teamwork into something more fruitful and enjoyable for members. This improvement may be associated with the need for students to develop the ability to work in groups.

Regarding the product planning phase, the current study showed that the three most difficult items (areas of knowledge) to be planned were Time (15.3%), Human Resources (14.6%) and Scope (13.9%). In the research developed in 2013, recalling data from this same questioning, the most difficult areas of knowledge were Cost

(23%), Time (21%) and Scope (13%). Comparing the above items, it is concluded that even after a few years the Time Plan and the Product and Project Scope continue to be a source of great difficulties for the students.

At the end of the course, in present research, students' knowledge gain in product development process was High (62.5%) and Intermediate (35.4%). In contrast, in research developed in 2012 show High (72%) and Intermediate (27%). These number present that the PBL practices is an important approach to use in product development course. On the other hand, the level of gain presents a variation. The causes of variation can be: the student's preference for the course, lack of commitment of the students, student's profile, student's level of ripeness.

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Pedagogy in Engineering: A proposal to improve the training of Chilean engineers

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Abstract

This paper presents the results of a survey focused on the interests and needs of academic training related to the different pedagogical aspects that influence the training of engineers in the engineering faculties of chilean universities, seeking to improve the quality of teaching and the academic training.

The research was organized in the frame of the "Pedagogy in Engineering in Chilean Universities" project, led by the Technische Universität Dresden (TUD) of Germany, funded through of DAAD and consisting of a group of academics from engineering faculties of three Chilean universities: Universidad Autónoma de Chile (UA), Universidad de Magallanes (UMAG) and Universidad de Talca (UTALCA). The objective of the project is to develop tools to determine the training needs of trainers of engineers in the pedagogical field.

Methodologically, an instrument was developed for the assessment of needs, based on specific theoretical concepts of the engineering training as well as the experience in research projects of the TUD in this area. In the gathering of information, 114 chilean academics participated, distributed among the different specialties that the engineering faculties of the three participating universities impart, among which stand out: chemical engineering, mechanical engineering, computer engineering, electrical engineering, construction engineering, industrial engineering and commercial engineering.

Among the main results obtained, it is worth noting that more than 90% of the respondents stated their interest in improving the pedagogical area focused on the training of engineers, but they presents time constraints to participate in a training and to attend this type of activities. At the same time it is possible to point out that the main areas of interest to receive training are: evaluation, ICTs and methodologies of teaching learning.

Based on the description given by the results of the surveys, we are currently working on the design, implementation and evaluation of an on-line training course aimed at teachers and academics at engineering faculties of Chilean universities.

Keywords: Pedagogy in engineering higher education   Teacher training   Pedagogy for professionals Pedagogical skills.

1 Introduction

Engineering Pedagogy, as a branch of Engineering Education, was originated in Germany more than 60 years ago. Also, a society for this discipline, Die Intenationale Gesellschaft für Ingenieurie Pedagogik (IGIP) exists for more than 40 years. These endeavors demonstrate the importance that has been granted, worldwide, to the improvement of the teaching methods, theoretical and practical, for the training and education in the technical and engineering fields, to satisfy the needs and expectations, both of students and employers.

The PEDING Project is a binational university effort – Germany and Chile - with the purpose to study and to develop a didactic methodology focused on the training of engineering lecturers and instructors at higher education engineering schools of Chilean Universities.

This initiative is relevant at present times, because it is the product of the concern of higher education institutions about the pedagogical specialization and training of engineering schools faculty, training that should have a positive impact in the reduction of academic failure and dropout of many, given that the lecturers would be knowledgeable in pedagogical and didactic principles, teaching and learning methodologies, and evaluation methods specially aimed to the formation of engineers through the Engineering Pedagogy approach.

In this context, three Chilean universities: Universidad Autónoma de Chile, Universidad de Talca y Universidad de Magallanes in collaboration with TU-Dresden, and DAAD support and funding, host this initiative, and gather and analyze the pedagogical needs of these institutions, to enhance the quality of the teaching process at the engineering schools.

1.1 Theoretical aspects

In 1951, Prof. Hans Lohmann, in his quest to systematize and to professionalize at an institutional level the teaching and research in engineering, founded the Engineering Pedagogy Institute (Institute für Ingenieurpädagogik) at The Dresden Technical University (Technische Universität Dresden, TU Dresden). Lohmannn specifically concentrated his work in the relationship between the "Technique" (Technik) and the "the teaching of the Technique" (Technicklehre). Thus, establishing with this concept the foundations of Engineering Pedagogy, whose aim is no other than the conformation of teaching and learning processes that are specific for the technical and technological spheres. During time, along with new demands on business and Industry and the developement of new technologies which have generated increasing training requirements in the field of engineering education, they also bring with them the developement of social and communication skills of engineers, allowing them to have an improved performance in the production structures of modern societies. Dr. Steffen Kersten (2015), a Professor at TU Dresden and general Coordinator of the "Engineering Pedagogy in Chilean universities" (PEDING) Project, proposes a scheme that describes the factors that influence and condition engineering education: The economic and production sectors of a country, engineering sciences, society and culture of the country, and the individuals who study engineering (see Kersten, Simmert, Gormaz, 2015).

Research in engineering education and didactic leaded by "The Institute for Didactic for the professional en technical formation" at TU-Dresden, in charge of Prof. Dr. Hanno Hortsch (General Director PEDING and President of IGIP) show numerous contributions that can deliver systematic training offerings in engineering pedagogy for faculty and instructors of engineering schools at universities in different countries: These training is specifically targeted to the needs of modern engineering in order to allow an improvement in the quality of teaching and the education of engineering students at engineering schools, thus, distinguishing itself from the generic pedagogical training that are usually offered in many higher education institutions, training that does not consider the specific needs of each discipline and profession.

Under this perspective, the PEDING Project Chile, which central objective is the design, implementation and evaluation of a training course for instructors and academics belonging to Chilean faculties of engineering. At this point It is important to highlight that this project was prepared and elaborated in a collegial way, voluntarily and collaboratively, by the researchers of the three Chilean regional universities and TUD, and proposed, by the researchers, to the senior academic authorities of their respective institutions. At the same time, teachers belonging to each of the Chilean engineering faculties were invited to participate voluntarily in the process of raising the pedagogical needs. Moreover, the format of the course (Bi-learning) was adopted considering the requirements of the teachers surveyed, regarding the importance of flexibility, and finally, the teachers who take the course will also do so voluntarily, motivating them to register in it by granting a certification on the completion of an international training program. Also, horizontal collegiality was manifested among the TUD researchers and those of the Chilean universities, since the former agreed to adapt the original model to the particularities of the Chilean university culture.

Firstly, an instrument was generated for collecting information about the academic interests and needs in the scope of engineering educación. In the framework of this Project, Dr.(c) Diego Gormaz designed a questioner to gather data on the training requirements of lecturers at engineering faculties from the results of the research in this matter† carried out by TU Dresden in Saxony (Germany). This study revealed the following needs: Didactic foundations of planification, implementation and analysis of academic teaching, design, selection and utilization of didactic media, design of communicative processes in academic teaching, design and implementation of control and evaluation processes, and the structuring of courses and syllabi (vase Köhler, Umlauft, Kersten, Simmert 2013, p. 17-18). The results of this research created the bases of a training course offered in 2012, modeled from the learning module structure according to IGIP (International Society for Engineering Education). Through an analytical adaptation of the results of this study and the module structuration of the training course, Gormaz (2014) systematized in clusters the following categories and indicators/aspects (see Table 1), which later were used in the recollection instrument on teaching needs of the engineering faculty of the three Chilean universities (see Gormaz, 2014).

This instrument and indicators seek to obtain information about: ***i)*** characteristics of lecturers (years of experience, subject matter, etc.), ***ii)*** experience and needs related to engineering didactic fundamentals, ***iii)*** requirements for the structuration of Teaching - Learning forms in a university context, and the setting of objectives and contents of an engineering degree, and, ***iv)*** identification of strengths and weaknesses, together with the conditions to enroll in a training course. It is important to highlight that the results about the needs in PEDING were used in the developement of the training modules.

Table 11. Instrument Indicators.

I. ENIGINEERING DIDACTICS FUNDAMENTALS	
Category	Indicator/Aspect
I.1. Design of teaching-learning processes	I.1.1. Psychological foundations of the work and action of teaching and learning
	I.1.2. Theoretical and practical bases of engineering didactics and learning
	I.1.3. Didactic Principles
	I.1.4. Organisation of the teaching – learning processes for the training in engineering sciences
	I.1.5. Structuring of the teaching – learning processes for the training in engineering sciences
I.2. Didactic media for teaching in engineering	I.2.1. Concepts and classification of didactics media
	I.2.2. Functions of didactic media and technological tools
	I.2.3. Field of action of didactic media
	I.2.4. Elaboration of didactic media
I.3. Communication	I.3.1. Design of communication processes
	I.3.2. Monologic and dialogic Communication procedure in education
	I.3.3. Conflict identification and resolution
I.4. Control and Evaluation of the learning outcomes in engineering education.	I.4.1. Registration and evaluation of the learning outcomes at universities
	I.4.2. Operalisation of Learning outcomes
	I.4.3. Procedures for the registration of learning outcomes.
	I.4.4. Evaluation of the learning outcomes.
II: FORMS OF STRUCTURING THE TEACHING – LEARNING PROCESSES IN UNIVERSITY CONTEXTS	
II.5. Lectures (theoretical courses)	II.5.1. General structure of a University course planning
	II.5.2. Preparation of a university course
	II.5.3. Execution of a university course
	II.5.4. Feedback in a university course
II.6. Laboratory practicum/ self-study	II.6.1. Laboratory training
	II.6.2. Experiment functions in the teaching – learning processes
	II.6.3. Excercises and self – study planning
II.7. Engineering internships, written reports, research colloquium	II.7.1 Engineering Internship preparation and research preparation
	II.7.2 Support systems for internships and for autonomous research
	II.7.3. Intrenship analysys and research activities analysis
III: DETERMINING THE OBJECTIVES AND CONTENTS OF ENGINEERING STUDIES	
III.8. Determination of the Study programme objectives	III.8.1. Analysis of the activities in engineering
	III.8.2. Analysis of the activities related to an university engineering study programme
	III.8.3. Analysis of social aspects in engineering
	III.8.4. Analysis of personal aspects in engineering
III.9. Determination of the	III.9.1. Fundamentals for the determination of contents of an engineering Study programme

† Project "Ingenieurdidaktik an Sächsischen Hochschulen, e-Didact 2010-2012"

Study programme contents	III.9.2. Contents determination of an university sudy programme with regard to the academic activities III.9.3. Contents determination of an university sudy programme with regard to the societal activities III.9.4. Contents determination of an university sudy programme with regard to the personal activities

2 Methodology

To conduct a research study with a greater dynamic, a "cross – focus" strategy was applied, as proposed by Lincoln and Gubba (2000), given the need to integrate the opinions of the participants with the assessment of pedagogical teaching needs and interests, that are most required for the education of engineers. Thus, in this way, it was called upon a mixed research design of the concurrent execution type, *i.e.* without a sequence and in parallel, for integrating the obtained data (Onwuegbuzie y Johnson, 2006).

2.1 Population and available sample

The sample of this study was composed by 144 academics of the Faculties of Engineering of the three universities, considering the indications of Hulland (Hulland et al., 1996), who suggest using a minimum sample of 100 individuals. The final sample consisted of 54% of lecturers belonging to Universidad Autónoma de Chile, 26 % to Universidad de Magallanes, and 20 % to Universidad de Talca.

2.2 Instrument

With a view to identify the training needs and interests in the pedagogical aspects requirements of major importance for the formation of engineers, an opinion poll type instrument, with open and closed questions, was applied. The characteristics of this instrument is described in point 2.1 above, and it was oriented to identify the perceptions about the teaching needs of different pedagogical aspects related to the engineering subjects at universities. Table N°2 presents the dimensions and conceptual categories of the instrument.

Table 2. Dimensions of the instrument items.

DIMENSION	ITEM GENERATING CONCEPTUAL CATEGORIES
Fundamentals from the point of view of Education Science	Knowledge about the procedures for the recollection and measurement of learning outcomes. Knowledge about the effective design of learning outcomes measurement Evaluation and assessment of learning outcomes. Knowledge about the fields of action of the didactic media and ICT Knowledge about the design of didactic media for the teaching – learning process.
Engineering didactics	Knowledge for determining teaching contents in engineering for the personal, technical and social activities of engineers. Structuring of teaching – learning processes for the scientific education of engineers. Theoretical and practical knowledge about didactics for the teaching and learning in engineering. Didactic principles for the teaching – learning process in engineering. Fundamentals for determining the technical contents whithin de engineering field. Knowledge about special teaching-learning strategies at university level. (Case study, observations of learners, among others). Knowledge and Skills for the preparation, execution and feedback of teaching. Knowledge about the design of teaching-learning processes for laboratory work. Analysis of specific topics about the concrete activities of engineers and specific knowledge from the engineering sciences. Organisation of the teaching – learning processes for the scientific education of engineers

Source: Results report, Projekt-ID: 57060070. March 2015. Pedagogía en Ingeniería para Universidades chilenas, DAAD

2.3 Procedure

The instrument was individually applied, considering the ethical aspects according to the Chilean social sciences research criteria. Once the data were gathered, the research process had to phases. Phase (T1), corresponded to information collection of the closed questions carried out by the research teams of the three universities. The statistical analysis applied was exploratory-descriptive with the aim to raise problems. The second phase of the study (T2) examined the open questions of the sample through a textual content analysis by codifying the discourse of each of the 114 academics, based on the item generating conceptual categories.

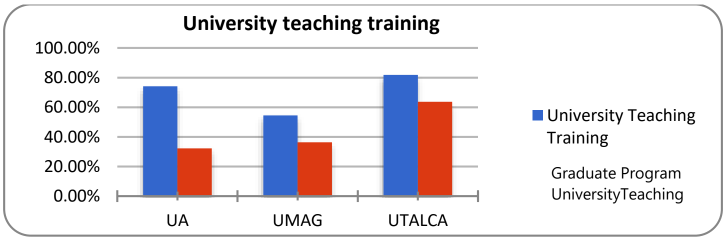
3 Characterization and obtained results

The characterization and the results obtained with the surveys applied to the academics of the Faculties of Engineering of the three Universities are presented below. These results were analysed in three dimensions: (1) Characterization of the group surveyed / general information of the academics, (2) Perception and needs in pedagogy in engineering, and (3) Open questions.

3.1 Characterization of the sample / General information of academics

The selected sample of academics that participated in the survey in each university was approximately 30% of the total number of academics attached to each of the Engineering Faculties. In total, 117 academics were gathered (62 AU, 33 UMAG, 22 UTAL) with 23% women (15 AU, 11 UMAG, 1 UTAL) and 77% men. Of the total respondents, 64% were engineers by profession (56% UA, 67% UMAG, 81% UTAL), the rest had similar professions that help to complement the total training of the future engineers. As for the respondents' ages, more than 40% of survey participants are between 30-40 years old and approximately 11% are over 60 years old. In relation to years of teaching experience, over 75% is between 1-20 years (79% UA, 76% UMAG, 72% UTAL). Of the total number of participants, 70% have been trained in university teaching (74% UA, 55% UMAG, 81% UTAL) and approximately 39% (32% UA, 36% UMAG, 64% UTAL) have participated on graduates/magister programs in the area of university teaching.

Figure Nº1: Percentage of participants with university teaching training and diploma or teacher in university teaching, separated by university.



3.2 Perception and needs in engineering pedagogy

In this section, the results about the perception of the respondents regarding the need for different skills and pedagogical tools for university teaching in engineering careers are presented. It was asked "*How necessary do you consider the following aspects of engineering pedagogy in relation to your teaching experience?*" For this section, 28 aspects were considered based on the indicators of Table 1, being the most relevant those related to the evaluation methods, among which stand out with more than 90% of the preferences aspects such as: "*Evaluation and assessment of achieved learning*" *and* "*Knowledge about design for effective measurement of achieved learning*". Then with more than 85% of the preferences are "*Structuring of teaching-learning processes in the scientific training of engineers*", "*Use of didactic resources and information and communication technologies* (ICTs). *For instance: support elements such as projector, blackboard, materials, etc.*", "*Knowledge about procedures of collection and measurement of achieved learning*"," *Knowledge about collection procedures and measurement of achieved learning*" and "*Knowledge about the preparation and valuation of professional practices and research activities*".

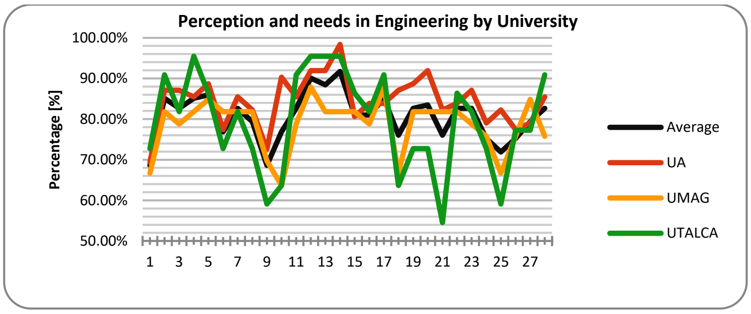
Among the aspects considered less relevant (less than 70% of the preferences) were found: "*Psychological foundations for teaching and learning*" and "*Dialogic and monologic communicative processes for teaching*". It is important to note that all aspects had at least 60% relevance for the respondents.

The results by university do not suffer major modifications (Figure 2). But it is observed that for the participants of the UTALCA, there are three aspects that obtain preferences less than 60%: "*Dialogic and monological communicative processes for teaching*", "*Knowledge about strategies to support professional practices and independent research activities*" and "*Analysis of the personal scope of engineering in Chile*". One possible explanation for these percentages is that the majority of the UTALCA participants have training in university teaching and also due to the institutional model that has been implemented for some time, so that the needs in that institution are not reflected with these aspects.

Some discussed aspects present a great difference between the institutions. In 3 aspects, the UA has preferences above 85%, while UMAG and UTALCA are under 66%: "*Recognition and resolution of conflicts within the classroom*", "*Planning of activities for individual study*" and "*Analysis of the personal scope of engineering in Chile*". Another aspect where there is a marked difference is "*Knowledge about strategies to support professional practices and independent research activities*" where the UA and UMAG have preferences over 81% while UTALCA does not reach 55%. These differences may be due to the different programs given at each University, as well as to the institutional and social context and to the training given to the participants.

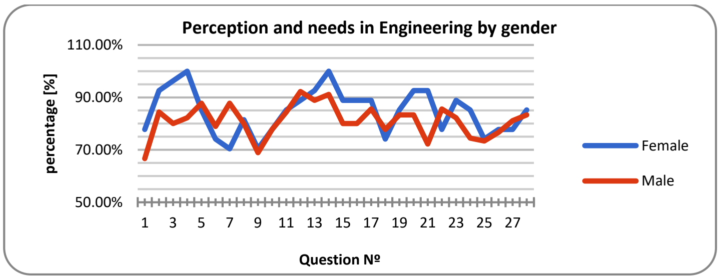
By grouping the participants by gender (Figure 3), the female participants (27) have 100% preferences on aspects 4: "*Structuring of teaching-learning processes in the scientific training of engineers*" and 14: "*Evaluation and assessment of achieved learning*". In the case of men (90), the aspects 12: "*Knowledge about the design for effective measurement of learning achieved*" and 14: "*Evaluation and assessment of learning achieved*" have preferences of 92% and 91% respectively.

Figure Nº2: Relevance of the different aspects consulted about perception and needs in Engineering by University.



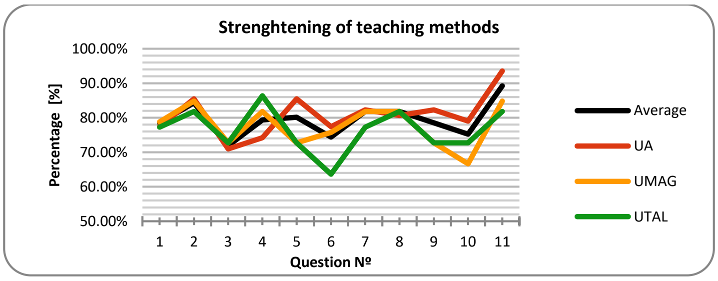
The worst evaluated aspects by the female gender correspond to the 7: "*Knowledge about the design of didactic means for the teaching-learning processes*" and 9: "*Dialogic and monological communicative processes for teaching*", both with 70% of preferences, while for males the worst evaluated aspects correspond to 1: "*Psychological foundations for teaching and learning*" and 9: "*Communicative dialogic and monological processes for teaching*" with 66% and 69% of preferences.

Figure Nº3: Relevance of the different aspects consulted about perception and needs in Engineering by gender



With respect to the results obtained in the 11 questions about strengthening of teaching methods (Figure 4), respondents considered all aspects with relevance over 70%. Among the aspects considered, the most relevant are: "*Use and development of new didactic means in the training of engineers*", "*Design, choice and use of didactic means*" and "*Planning and structuring of teaching-learning processes at university level*", all of them with more than 80% of preferences. The aspects with the lowest relevance were the aspect 3 "*Realization of communicative processes for teaching at university level*", 6 "*Planning and materialization of evaluation and evaluative processes*" and 10 "*Curriculum development for academic training at the university level*".

Figure 4: Relevance of the different aspects consulted on the strengthening of teaching methods.



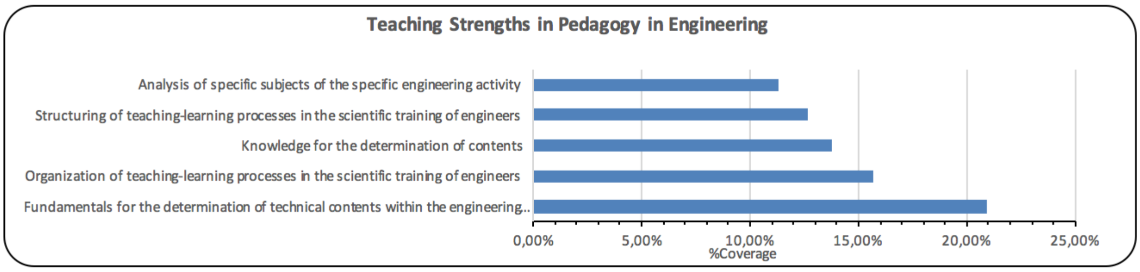
Analysing the results by university, aspect 5 "*Resolution of specific problems on the design of instruments for the assessment of teaching-learning processes*" appears as one of the worst evaluated in both the UMAG (72%) and UTALCA (72%) while in the UA is one of the most relevant (85%).

3.3 Open Questions

In this part of the survey we asked about 4 aspects: (1) strengths in engineering pedagogy; (2) aspects to be improved in the teaching task; (3) interest and availability to train in the engineering pedagogy area; and (4) conditions necessary to attend a training in engineering pedagogy

Regarding the strengths of the teachers in the sample, the five most relevant results are grouped in strengths associated with: The *fundamentals for the determination of technical contents within the engineering area* (20.9%); the *organization of teaching-learning processes in the scientific training of engineers* (15.69%); the *knowledge for the determination of contents of teaching in Engineering in relation to personal, technical and social fields of the work of Engineers* (13.77%); the *structuring of teaching-learning processes in the scientific training of engineers* (12.68%) and the *analysis of specific subjects of the specific engineering activity and knowledge from the engineering sciences* (11.30%) (see Figure 5).

Figure Nº5 Teaching Strengths in Pedagogy in Engineering



With respect to the aspects to be improved in teaching, the five most relevant categories are grouped based on: *Fundamentals for the determination of technical contents within the area of engineering* (35.03%), *Evaluation and assessment of achieved learning* (18.77%), *Didactic principles for teaching-learning in Engineering* (12.70%) and *Knowledge and skills for the preparation, execution and feedback of teaching* (12.22%) (See Figure 6). In this review emerge two relevant categories associated to the improvement of the infrastructure and the time for preparing the teaching.

Figure Nº6. Aspects to improve in engineering pedagogy

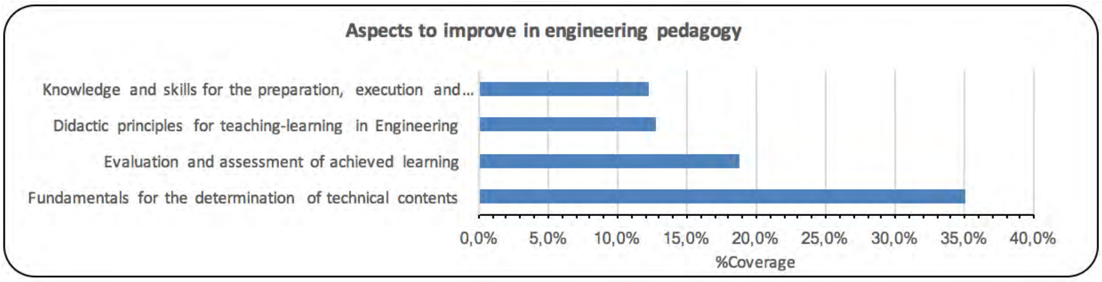
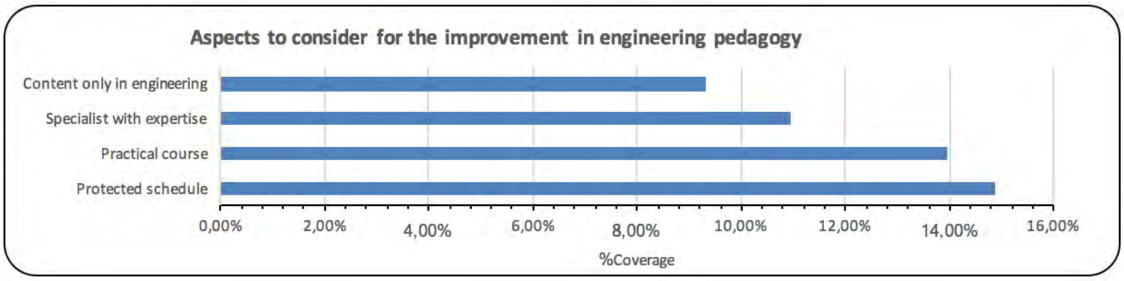


Figure Nº7. Aspects to consider for the improvement in engineering pedagogy



Regarding the interest in training, 83.44% would be willing to improve and only 8.06% would not. These results are mainly associated with lack of time, however they are available to review associated material, without having to attend formal courses. Finally, in response to the question related to the necessary conditions to attend an engineering pedagogical training, the results indicate that the schedule is a factor (6.95%), and in that sense the 14.86% indicate that a fixed and protected schedule for full-time teachers, and a weekend or evening (3.34%) for part-time teachers (4.78%) should be considered. Another condition indicated is that they should be certified courses (4.17%) and part of the remuneration (1.62%). They also consider it important to have a practical course (13.96%), dictated by a specialist with expertise on the contents (10.95%) and ideally be a course dictated by engineers, with content only in engineering 9.31%) (See Figure 7).

4 Conclusions

This work aimed to show the pedagogical and didactic needs found in the academics who teach in the engineering faculties of three Chilean universities (two public and one private), based on the knowledge and experiences in the field of Engineering Pedagogy of the TU-Dresden.

From the results obtained it is possible to conclude, that the academic communities of the engineering faculties studied, tend to converge on the pedagogical capacities that are required to train the future engineers. It can also be observed that, both public and the private universities, there is a need to update and refine the methods currently used to deliver and evaluate knowledge, taking advantage of the available technological advances and tools.

The main relevance of this joint work was to show that Chilean academics from different engineering faculties are willing to train and incorporate systematic knowledge and skills, based on the tools of Engineering Pedagogy, to enhance the skills they already possess and thus improve the strategies and methods of teaching directed to its students. As shown on the results, the academics consider a priority to be trained in: (1) Evaluation and strategies of results measurement, (2) design of teaching processes, and (3) design of learning resources, among others. To meet these and other needs, teacher-training modules were developed and subsequently implemented. With these actions it is expected to increase the academic success of the engineering students of these universities; and to develop an improvement line in the area of engineering pedagogy for teachers of engineering faculties, using the results obtained in this project. In this context, it is observed that the participation of these academics would be conditioned mainly by the time involved and the ease on the part of the universities, to reduce the amount of hours that the academic has in teaching and academic management, while doing the training.

5 Acknowledgements

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Product Design Methodology Applied to develop a "Catapult" Project Based Learned – From Product Design Specification until Catapult Launch

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Abstract

With the aim of developing the skills of Engineering students of the Federal University of Santa Catarina, was proposed during the course of Methodology of Project and Product that the students apply the knowledge acquired and carry out a complete project. The proposal requires the realization of the project planning, the informational and conceptual projects, also the production of the preliminary project and finally, the construction of the product which, in this case, is a catapult. This article consists of the project of a team of students. The team has developed a catapult that besides being within all the necessary design specifications, also has an artistic touch, since it was designed to have the appearance of MASP (Museum of Art of São Paulo). The PBL approach contributes to a better development of responsibility for compliance with the activities and agreed deadlines.

Keywords: Methodology of Project and Product; Catapult; Informational Project; Conceptual Project

1 Introduction

During the development of a product, several preliminary projects are required to be manufactured in a sensible and planned manner. The impacts that can be caused by the product in the society must be known during the project and molded according to what is expected of the product.

For the development of the product be given in time and quality, a project organization is required. The product will only be fully studied, evaluated and complete, if the project is well executed.

With the intention of applying the knowledge acquired by studying Methodology of Project and Product, It was performed a complete design for the design of a Catapult. This project was aimed at developing product planningThis planning took place through the application and elaboration of scopes, preliminary and informational projects, time management and use of CANVAS. In addition, it was decided to develop the manufacturing and assembly project, and also apply the QFD matrix, the AHP method and develop a TRIZ model.

2 Scope

The development of the catapult project aims mainly at the study, experimentation, manufacturing and, consequently, learning about Project Product Management. Allied to the main objective, is added the one of the experience and learning of work and group conviviality.

The organization and planning for the project development starts with time planning. It is extremely important to know how to manage time and follow the planned stipulations. To be able to observe the progress of the project and to control the completion of each task, it is necessary to use a manager. In this project the team used, optionally, the Freedcamp. Through this it was possible to have control of time and progress of each topic.

In addition, human and financial resource plans have also been developed. Responsibilities were equally distributed among the members and each was entrusted with a part of the project.

2.1 Project

The development of a project progresses according to its organization and its management. The realization, in time imposed, of the necessary tasks for the progress of the same is of extreme importance for its conclusion. There are several possible ways to manage a project in view that, through this type of information, it is possible to manage the time, progress, activities to be performed, etc.

The *Project Model Canvas* presents itself as a tool to support the planning of projects. Through this tool you can have an overview of the product that is in planning. Using the tool PMCanvas there are an initial guide of topics to be thought early in the project, such as the justifications, objectives and benefits, as well as the product requirements. It is also possible to visualize in a practical way the conditions of accomplishment of the work listing the restrictions, assumptions and the expected deliveries.

In the CANVAS model developed by the team, the greatest difficulties can be observed in the figure below:

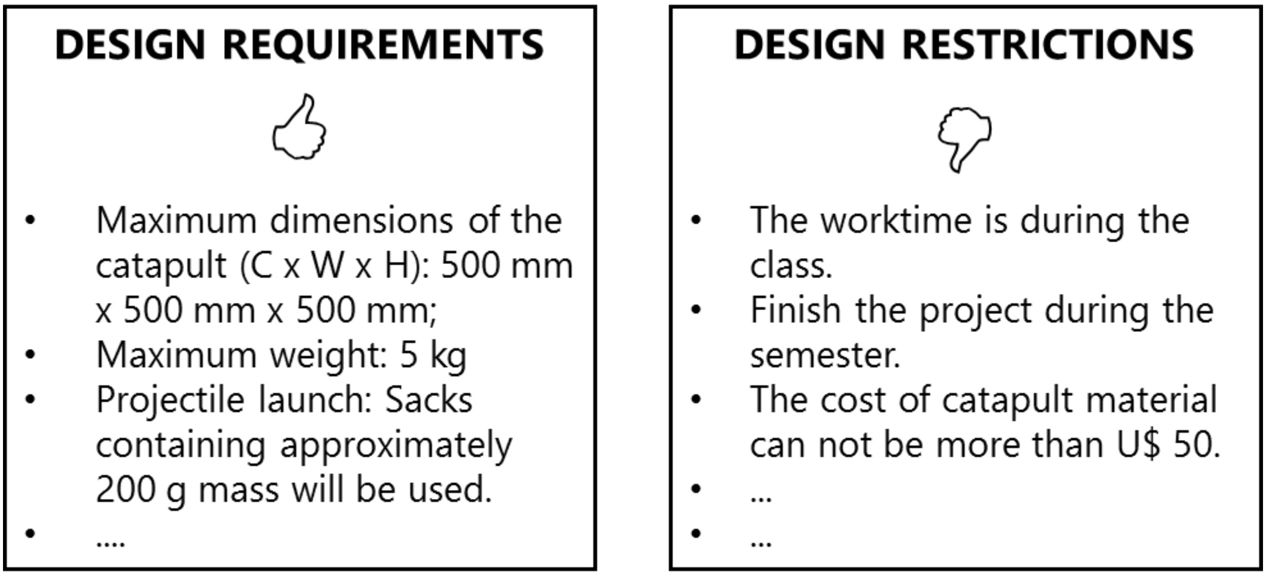

Figure 1. Project requirements (left), project constraints (right)

The requirements and constraints were the major problems encountered in the design of the catapult. Mainly the restrictions. The time for designing the catapult was small, in addition, expenses could not exceed the ceiling of R$ 100.00 stipulated by the team. The latter cited influenced the purchase of materials.

After having the CANVAS model completed, the development of the project and the application of the matrices began.

In this second moment, there is information that needs to be stoned, knowing the clients' needs, for example, is very important to be sure of the usefulness of the product. Through this information it is possible to shape the project so that it meets the needs suggested and specified by the clients.

Deployment of the QFD matrix in this case is vital. The matrix QFD (Quality Function Deployment) is basically a method where the needs and requirements of the project are informed and through this information to analyse its development. Through the QFD matrix it is possible to know the needs of the clients and induce the project to solve them. That is, the matrix is generated so that the project meets the demand of customers' needs.

Therefore, its implementation is of great importance since, through it, it is possible to make a project with the certainty that it will be suitable for the clientele.

For a better understanding of the QFD matrix application, below a part of the QFD matrix developed by the team:

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	▼	▲	▲	x	▼	▼	▼	x
				Quality Characteristics (a.k.a. "Functional Requirements" or "Hows") / Demanded Quality (a.k.a. "Customer Requirements" or "Whats")	Number of moving parts	Number of devices for vertical and horizontal aiming	Number of systems (Damping and dissipation of energy)	Drop height to resist	Intensity of the application force required to trigger the trigger	Number of system modules	Measures of transport devices	Number of required operators
1	9			Precision	⊙	⊙	▲		▲	⊙		▲
2	9			Ergonomics	▲				⊙	▲	⊙	⊙
3	9			Fall resistance	⊙	⊙	⊙	⊙		○	▲	
4	9			Ease of transport	○	○	▲	▲	⊙	⊙	⊙	▲
5	9			Ease of use of the trigger device	▲	○		▲	⊙	▲		⊙
6	9			Ease of installation of the launching device	▲				⊙			⊙
7	9			Ease of adjusting the sight	▲	⊙			⊙			⊙

Figure 2. QFD Matrix

The morphological matrix can also serve as a complement to the QFD. This array type is a solution method for combinations of functions, objectives, processes or ideas. It consists of an arrangement of different elements or parameters aiming to facilitate the possible combinations and find a new solution to the problem.

To develop the morphological matrix, the following steps must be taken:

1. Identification of functions or operations and parameters;
2. Completing the first column of the array with the functions or parameters;
3. Completing the second column of the matrix with principles of solutions;
4. Completing the other columns with alternative conceptions, using graphical representations, images or descriptions.

After analysis of the QFD and Morphological matrices, the most feasible conceptions were selected and did not conflict with the others.

2.2 Application o TRIZ

TRIZ (Theory of Inventive Problem Solving) intends to solve design problems without others being generated. Over time, it was possible to note the importance of method since it has become increasingly expensive not to use it. TRIZ is an initiative of G. S. Altshuller for the purpose of solving inventive problems.

This model is capable of collecting information and guiding the best possible solution. It is also viable, using TRIZ, find conflicting points within the project and thus, having knowledge of these problems, seek for a solution.

The first and second applications of TRIZ's inventive principles for this project can be seen below:

Table 1. First application of TRIZ

Design requirement to be optimized	Number of devices for vertical and horizontal aim	
TRIZ Engineering Parameter to be optimized	36. Device complexity	
Conflicting Project Requirement	Drop height to resist	
Conflicting Engineering Parameter	14. Resistance	
Inventive principles	Principles of solution	Explanation
2. Extraction	Remove aiming devices considered unnecessary	With fewer aiming devices, it will be easier for the catapult to withstand
13. Inversion	Changing the position of pointing devices	With the aiming devices fixed in the safest places of the catapult, it will be more difficult for them to break in the fall

Table 2. Second application of TRIZ

Design requirement to be optimized	Number of damping and dissipation systems	
TRIZ Engineering Parameter to be optimized	36. Device complexity	
Conflicting Project Requirement	Weight	
Conflicting Engineering Parameter	2. Weight of the static object	
Inventive principles	Principles of solution	Explanation
2. Extraction	Remove damping systems considered unnecessary	With less damping systems, the catapult will be lighter
35. Transformation of the physical and chemical states of an object	Changing the density of damping systems	Keeping the original size of the damping systems, the weight of the catapult will decrease if it adopts systems with lower density

Through the total application of TRIZ it is possible to observe the project and the conflicts existing in the development of it. Description of Selected Conception

2.3 Description of Selected Conception

Initially, four alternatives of catapult conceptions were analyzed: Ballista, Mangonel, Trebuchet and Twist. It is known that regardless of the generated design there may be solutions and principles that improve the performance of one or more requirements, which implies that the concept to be applied and the average of the best solution based on weights and amounts, is not the best solution in itself.

After surveying the alternatives, the team needs a method to select the catapult that best pleased the requirements. For this, we use the PUGH matrix.

The matrix in question is constructed based on design requirements and the weights and amounts generated in the QFD matrix. A note is assigned to each design. The final value is the sum of the weight for the requirement multiplied by the note given to each of the conceptions.

Below, the PUGH matrix developed by the team:

Table 3. PUGH

Project Requirements	**Weight**	**1**		**2**		**3**		**4**	
Number of moving parts	302,8	4	1011,2	2	605,6	4	1211,2	3	908,4
Number of devices for vertical and horizontal aim	491,1	4	964,4	2	982,2	3	1473,3	3	1473,3
Number of damping and dissipation systems	309,9	4	1239,6	1	309,9	3	929,7	3	929,7
Drop height to resist	302,5	5	1512,5	1	302,5	4	1210	3	907,5
Intensity of the application force required to trigger the trigger	372,4	4	1489,6	4	1489,6	4	1489,6	3	1117,2
Number of system modules	407,4	4	1629,6	5	2037	4	1629,6	3	1222,2
Measures of transport devices	84,9	3	254,7	0	0	3	254,7	3	254,7
Number of operators required	205,2	3	615,6	5	1026	3	615,6	3	615,6
Required training level of operator	216,9	3	650,7	4	867,6	3	650,7	3	650,7
Quantity of materials and tools used in manufacturing and assembly	333,5	4	1334	2	667	4	1334	2	667
Quantity of materials and tools used in repairs	94	4	376	3	282	3	282	2	188
Weight	112,5	5	562,5	1	112,5	4	450	4	450
Number of safety devices	87,6	3	562,5	4	350,4	2	175,2	3	262,8
Degree of aesthetic satisfaction	106,4	5	532	3	319,2	4	425,6	4	425,6
Amount to be spent on production	318	5	1590	1	318	5	1590	3	954
Percentage number of materials that are not offensive to the environment to be used	10,4	4	41,6	1	10,4	2	20,8	2	20,8
Number of tools needed for the removal of waste	53,2	4	212,8	4	212,8	4	212,8	3	159,6
Sum	3808,7		15779,3		9892,7		13954,8		11207,1

At the end it is important to evaluate which one obtained the best result and to analyse if there is any factor that makes it impossible to manufacture, such as budget extrapolation or lack of resources, as tools. If not, we continue with this conception.

By better serving the needs stated in the QFD matrix, where weights and amounts of customer needs were weighted, taking into account the resources of the team and the alignment with the project objective the "ballista" type catapult was selected to be performed.

For structural parts, wood and steel were chosen by the good ratio of strength and weight given the proportions of the product, because in addition to being cheap does not need extremely skilled professionals and good tooling for handling.

As an energy absorption system some hypotheses were raised and it was decided to use styrofoam between the levels of the catapult, because it has low density and provides low cost reparability.

An elastic was used to generate the necessary impulse for the receptacle to provide kinetic energy to the projectile. This was chosen because it meets the needs of easy reparability and low cost. The base for the projectile was inserted into a PVC tube, providing good containment and orientation at the time of firing.

For the equipment has the ability to hit targets, even if they are with horizontal deviation about catapult, A mechanism has been developed that consists of two overlapping plates and with an axis, which allows the rotation of the equipment. For height adjustment, the tube may be raised on the basis of a hinge.

Most joints were made using bolts and nuts, thus facilitating assembly and subsequent disassembly.

To meet the demands of aesthetic appeal and follow an art movement, the design of the catapult was inspired by the MASP (Museum of Art of São Paulo), which has architectural features of modernism.

The catapult model developed in SolidWorks can be seen below:

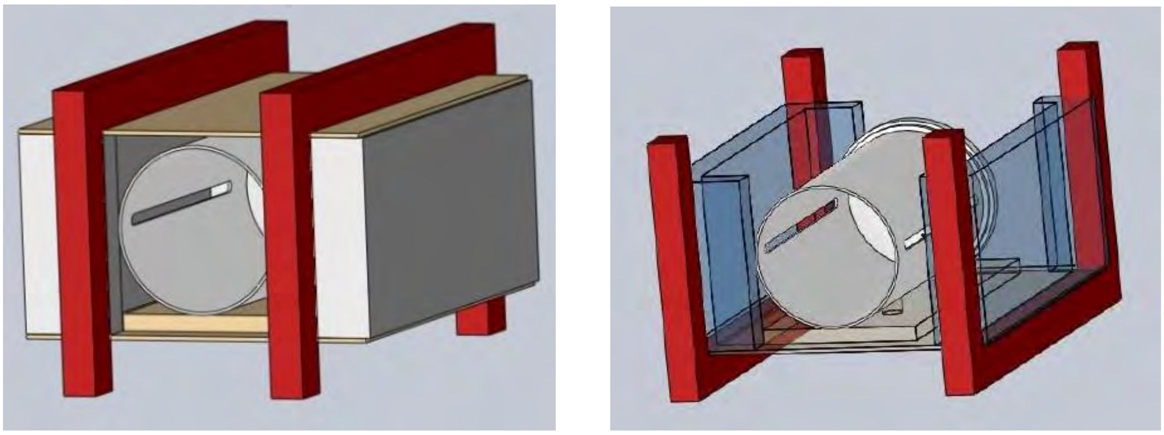

Figure 3. Catapult model developed in SolidWorks (right and left)

After the project the product was finally built. It followed all the information seen in the project and worked quite well. The catapult was able to hit the target and assured the team the first place in the best catapult competition developed for the course of Methodology of Project and Product.

3 Conclusion

All project requires a significant amount of time spent in its planning. Even so, there are problems that are not foreseen and that can occur in the progress of the project. The implementation of the QFD Matrix and mainly TRIZ provide a greater margin of assurance about the organization and functioning of the totalitarian project.

Through these implementations it is possible to solve probable problems without having any others. It is also possible to have greater project visibility and everything that is generated by it, such as: know how much it will affect the environment when it is discarded.

Therefore, it is concluded that the implementation of this information in the project is of extreme importance for its correct progress. In addition to great helpers in visualizing and completing each existing and necessary task.

The PBL approach contributes to:

- Experience real situations;
- Integrate various concepts of other disciplines;
- Develop divergent thinking;
- Stimulate the planning and execution of a plan of work;
- Students are motivated to work efficiently;
- Learn to work with short deadlines for developing activities;

Finally, the application PBL in this course allows a better development of responsibility for compliance with the activities and agreed deadlines.

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Biomimicry Applied in Engineering Education: a Case Study in PUC-SP

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Abstract

This paper analyses the experience of the short course "Biomimicry: innovation inspired by nature", and the accompanying prototype marathon, held at the Technology and Exact Sciences Week of the Pontifical Catholic University of São Paulo (PUC-SP) in October 2016.

For the activity two working methodologies were adopted: Biomimicry, in which students seek inspiration in nature's characteristics or phenomena to solve engineering problems, and the CDIO (Conceive, Design, Implement and Operate), applied in the development of prototypes.

In this matter, the objective of this work is to evaluate the central question: "Could the union of the CDIO and Biomimicry methodologies generate a transdisciplinary active learning approach capable of building theoretical knowledge applied in innovative and sustainable projects?"

The development of the short course was carried out in five days of activities, and the prototypes were developed in groups formed preferably by students from different engineering areas (civil, production and biomedical) and presented a free theme, chosen by the group itself.

The case study carried out in this article presents a critical analysis of the contributions of Biomimicry to innovation in engineering projects and prototyping using CDIO. We present the prototypes developed by the students and the general evaluations of limits and contributions regarding the course, as well as the union of these two methods of work.

As a main result, there were several difficulties related to the short time available for structuring the projects, and for the students to assimilate the methodological proposal that brought disruption with the common teaching standards. On the other hand, the junction between Biomimicry and CDIO points to a transdisciplinary approach, based on the solution of human problems, which provides the students' own construction of knowledge through the systematic application of the skills acquired in the project and in the implementation of the prototypes.

Keywords: Active Learning; Innovative Approaches; Engineering Education; Biomimicry; CDIO; Sustainability.

1 Introduction

The purpose of this work is to evaluate the central question: "Could the union of the CDIO and Biomimicry methodologies generate a transdisciplinary active learning approach capable of building theoretical knowledge applied in innovative and sustainable projects?"

The justification for joining the CDIO and biomimetic methodologies is based on a set of elements that characterize the current Brazilian scenario.

Since 2005 a set of public policies has provided the popularization of university education through the granting of government grants through the ProUni program, which between 2005 and 2016 provided scholarships to 1.9 million students, and student financing through the FIES program, which awarded between 2009 and 2016 about 5.6 million student loans to private universities. (INEP, 2016). In the year 2016, about 7.2% of the country's university students - approximately 215,000 students - were students of Engineering courses (INEP, 2016).

Despite this significant contingent of students, and a consequent 2-year increase in the average formal education (CAGED, 2017), productivity in the country did not increase substantially. Between 2000 and 2015, labor productivity increased only 9.5% in Brazil, while in Chile the increase was 19.8%. Growth rates were also significant in Colombia (18.9%) and Peru (36.8%) (The Conference Board, 2015).

Although productivity is affected by issues related to industrial processes such as access to technology and government incentives, the quality of education offered can be considered as one of the significant elements to understand the low Brazilian productivity: about 38% of university students are not fully literate (INAF, 2016), that is, the popularization of university education was not accompanied by an increase in the quality of teaching. Most of the students entering higher education have serious restrictions on their previous schooling and, consequently, about 55% of those entering higher education institutions end up dropping out of school (INEP, 2016).

As a way of dealing with the precariousness of students' previous education, several institutions have sought the construction of basic cycles of engineering courses capable of compensating the deficiencies of training of the students. In spite of some initiatives of insertion of active learning methodologies, in most of the Brazilian institutions the engineering education is still based on the passive learning of theoretical concepts that require previous knowledge and ability of abstraction not previously acquired by the students. Moreover, few times the academic approach deals with practice, being unable to demonstrate how the application of theoretical concepts to problem solving occurs.

In addition, Brazilian university education often ignores the creative capacity of students, although several studies in the field of teaching and work psychology have shown that the Brazilian population has a high creative capacity (Torrance (1966, 1990), Siqueira (2001), Reis (2001), Godoy (1996) apud Wechsler, 2001). The Brazilian people are extremely creative, and can deal in an extraordinary way with the adversity and the lack of resources that surround it, generating solutions of problems.

Over the last decades, the professional profile of the engineer required by enterprise and societal needs has changed. More than just a technical specialist restricted to his/her field of knowledge, it is currently required to the engineer to act as an articulator between different interfaces of the production process. In addition, engineers should be able to implement innovations in these processes. Consequently, professional success in this field depends not only on the theoretical knowledge of engineering, but also on skills developed through "hands-on" projects, as well as the ability to work in teams with professionals from different fields of knowledge.

Parallel to this demand, the growth of environmental problems has driven the search for sustainability in different sectors of science and technology. Due to the more restrictive environmental legislation and the demand of consumers, claim for the triple bottom line is increasing. Consequently, there is a growth in investment in high productivity processes based on automation, robotics and nanotechnology, which should be integrated simultaneously into a sustainable production matrix established through labor relations based on social responsibility and environmentally friendly.

In this context, the Product Life Cycle's study has focused on concepts such as the Circular Economy and *Cradle to Cradle* (C2C). It has also the tendency to seek, upstream from the production process, clean energy sources and renewable raw materials with a low environmental impact, and, downstream of the process, the search for reverse logistics for recycling, upcycling, reuse or even return to the natural environment with the least possible impact.

Faced with this scenario, it is believed that education in engineering should bring approaches capable of responding to these challenges. In pursuit of this objective, the short course "Biomimicry: innovation inspired by nature" was elaborated, accompanied by a marathon of prototypes, during the Exact Sciences and Technology Meeting of the Pontifical Catholic University of São Paulo (PUC-SP) at October 17 to 21, 2016.

The short course brought together two working methodologies as guides to the learning context: (I) Biomimicry, which studies models of nature to then imitate or inspire in these designs and processes to solve human problems. (II) And the CDIO, which seeks to develop in the stages of conceiving, design, implement and operate learning outcomes such as disciplinary knowledge and reasoning, personal and professional attributes, interpersonal skills, and the skills specific to the engineering profession.

2 Design and prototyping with the CDIO method

As pointed out by Crawley at al, "Over the last decade, there has evolved a broad sense that there is a need to create a new vision and concept for undergraduate education. One approach to this, recognizable to engineering faculty, is to engage this problem by applying an engineering problem solving paradigm. This entailed first developing a comprehensive understanding of the skills needed by the contemporary engineer, and then designing and education to meet these requirements". (Crawley at al, 2011, p.2)

In pursuit of this new concept of education, professors Edward F. Crawley, Johan Malmqvist, William A. Lucas and Doris R. Brodeur launched the first version of the CDIO syllabus in the early 2000s, supported by a method developed at MIT at the end of the 1990s. Through active learning using the CDIO method, students would have the opportunity to take an active role in their learning process by seeking practical problems, preparing them for real challenges to the authentic role of engineers in their service to society.

Focused on an international initiative for the development of this methodology, the authors left open the possibility of making adaptations in the method, according to the local reality of each educational institution as a way to allow the replicability of the methodology. Over the years, various contributions have been made to the initial method, giving rise to version 2.0 of the syllabus.

In the literature review we have observed the most applications of CDIO is in different undergraduate programs engineering and countries, like Aerospace and Aeronautical engineering in Singapore (Keng Wah, Tan, Chong, & Siew, 2015), Telematics Engineering and Computing Systems Engineering in Colombia (Ulloa, AG; Villegas, N; Céspedes, 2014), civil engineering in Canada (Brennan & Rosehart, 2011) and England (Guan, Millard, & Yang, 2008), various engineering programs in Denmark (Bennedsen J, 2012; Bruun & Kjaergaard, 2011) and China (Nengsheng, B; Peihua, G; Xiaohua, L; Guangjing, X; Yan, 2013). These countries have been undertaking comprehensive review of all main aspects involved in engineering education (program objectives, development of personal and team capabilities, application of active learning method, continuous improvement systems of programs, adaptable methodology for all engineering schools) and agreed that the application of CDIO was the best option for the development of techniques that allow students to master these skills.

The application format of CDIO is generally in a framework (an essential supporting structure that provides functionalities and/or solutions to the particular problem area), like the College of Engineering at Shantou University - China, that adopted a CDIO education framework to re-design curricula an course contents of engineering programs (Gu, Lu, Xiong, Li, & Shen, 2006) or in Rapid Prototyping Services (RPS) in engineering service processes and business to business service sales in Slovenia (Tenhunen, Niittymäki, & Aarnio, 2010), or like the O-CDIO that combines human-centered Design Thinking methods with Systems Thinking with the objective to educate engineering students to become problem definers in addition to problem solvers (Taajamaa et al., 2016).

The process of evolution of the methodology during the period between 1997 and 2015 can be seen at the timeline (Figure 1):

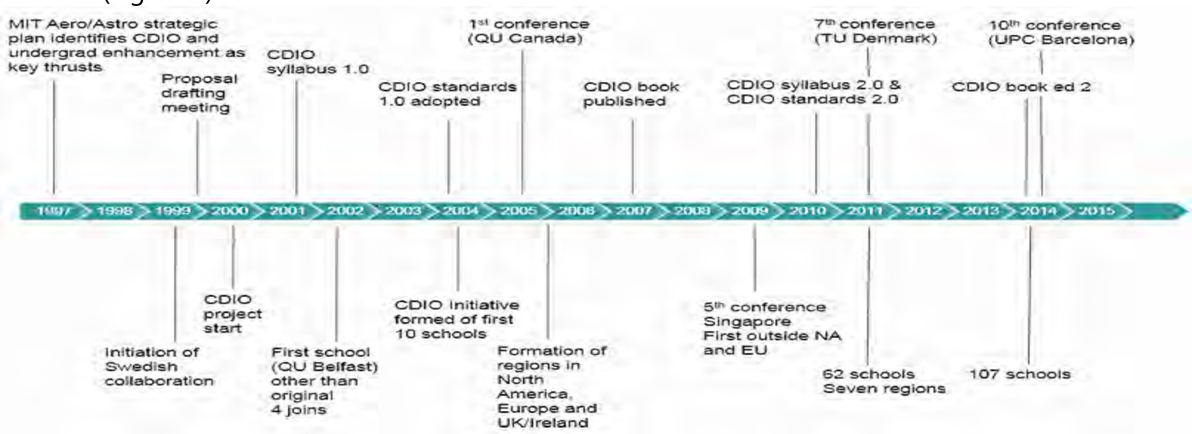

Figure 21.Timeline of the evolution of CDIO's methodology.Source: http://www.cdio.org/cdio-history

In general, it is possible to point out as main characteristics of the reformulated version the development of the following abilities:

1 Disciplinary knowledge and reasoning 1.1 Knowledge of underlying mathematics and science 1.2 Core fundamental knowledge of engineering 1.3 Fundamental knowledge, methods and tools **2 Personal and professional skills and attributes** 2.1 Analytical reasoning and problem solving 2.2 Experimentation, investigation and knowledge discovery 2.3 System thinking 2.4 Attitudes, though and learning 2.5 Ethics, equity and other responsibilities	**3 Interpersonal skills: teamwork and communication** 3.1 Teamwork 3.2 Communications 3.3 Communications in foreign languages **4 Conceiving, designing, implementing, and operating systems in the enterprise, societal and environmental context** 4.1 External, societal and environmental context 4.2 Enterprise and business context 4.3 Conceiving, systems engineering and management 4.4 Designing 4.5 Implementing 4.6 Operating

Source: (Crawleyat al, 2011, p.5)

In addition, version 2.0 of the syllabus seeks to align its practice with UNESCO's four pillars of education. The fundamentals of the 4 pillars would be directly aligned to the CDIO method (table 1):

Table 12. Comparison of the 4 pillars of UNESCO's education with the skills developed in the CDIO methodology

4 pillars of UNESCO's education	Skills developed by CDIO
Learning to Know, that is, acquiring the instruments of understanding	Technical Knowledge and Reasoning (or UNESCO Learning to Know)
Learning to Do, so as to be able to act creatively on one's environment	Conceiving, Designing, Implementing and Operating Systems in the Enterprise, Societal and Environmental Context (or UNESCO Learning to Do)
Learning to Live Together, so as to co-operate with other people	Interpersonal Skills: Teamwork and Communication (or UNESCO Learning to Live Together)
Learning to Be, an essential progression that proceeds from the previous three	Personal and Professional Skills and Attributes (or UNESCO Learning to Be)

Source: (Adapted from Crawley at al, 2011, p.8)

The authors further emphasize "The CDIO approach holds that the product, process, or system lifecycle (conceiving-designing-implementing-operating), should be the context, but not the content, of engineering education. (Adapted from Crawley at al, 2011, p.2)

Even though the focus of the second version of the expanded CDIO syllabus was expanded to include "Societal and Environmental Context", it is believed that the method's view remained limited by focusing only on the system lifecycle, presenting a limited view as well as the upstream and downstream sustainability of the production process. From this came the idea of joining the biomimetic and CDIO methods for the development of innovative products in engineering.

As observed, approaches and applications of CDIO methodology in undergraduate programs engineering are diverse, the present work tests the experience of the joint application of biomimicry and CDIO.

3 Biomimicry for engineering innovation

According to Janine Benyus "Biomimicry is a new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems". (BENYUS, 1997, p. p. 6)

Nature was generated, through hundred millions of years, systems and substances that have made life on earth what is today (Swiegers, 2012) providing solutions in nature to the most differents technical problems. Some technicals applications include structural coloration, photonic devices, biomaterials and composite materials, sensor systems, robotic and locomotion and ultra-lightweight structures (Lakhtakia & Martín-Palma, 2013). Like the application of biomimicry principles to urban infrastructure problem, fostering innovative and collaborative urban design (Taylor Buck, 2017) or the modeling of the aeromechanics of flapping wing microflyers, where aspects of aerodynamics at the scale are discussed (Sirohi, Martín-Palma, & Sirohi, 2013).

Some authors argue that it is already necessary to think of a philosophy of biomimetism, because their processes and applications that involves a new philosophical paradigm, of collaborations between scientists (biologists, ecologists, etc.) and technologists (engineers, architects, designers, etc.) so as to include research in philosophy and the humanities (Dicks, 2016)

In the present, scientific community explores all that knowledge and how we can replicate it in different settings and environments.

As examples of contributions of biomimetics for innovation in engineering, we can point the following examples: In the field of nanotechnology, the study of physico-chemical properties in phospholipids has helped engineers to assemble nanoparticles and nanostructures (Mann, S., 2008). In the field of biomedical engineering, regenerative medicine and tissue engineering are the ones that generate higher expectations, such as a biocompatible human tissue band derived from the regenerative processes of lizards (Hwang et al, 2015). In mechatronics, the motor mechanisms of animals and insects have been imitated, giving a new focus on machine mobility, previously limited to tires and wheels (Witte H. et al., 2004; Boxerbaum et al. 2012)

Regarding the importance of this new science, different studies have related biomimetic research with large-scale projects, analyzing their socio-economic impact in Europe, the United States and Japan (Hwang, J. 2015). According to industry analysts (Shimomura, M. 2012), by the year 2025 biomimicry could represent $ 300 billion per year of Gross Domestic Product (GDP), providing 1.6 million jobs, in the United States alone. According to the Fermanian Business & Economic Institute, which accompanies the development of this field of research, biomimetic patents, academic articles and research grants have increased more than five-fold from the 2000s to the present. In addition, according to Institute estimates, by 2030 biomimetics could account for about 425 billion US dollars of US GDP and 1.6 trillion US dollars of world economic output. (Fermanian Business & Economic Institute. 2013, p.5)

Biomimicry is an innovative approach that seeks sustainable solutions to human problems by incorporating patterns and strategies tested by nature as project solutions. The central idea is that through evolutionary process and natural selection nature has already solved many of the problems we are dealing with them.

The objective of applying biomimetics in engineering is to create products and processes that are efficient and sustainable, adapted to life on Earth in the long run. From this perspective, it is believed that the union of biomimicry with the CDIO method could contribute to the expansion of the skills developed by the CDIO method, preparing the student for market demands focused on sustainability.

4 The short course "Biomimicry: innovation inspired by nature"

As a way of testing the validity of the union of the CDIO and Biomimicry methodologies, the mini course "Biomimicry: innovation inspired by nature" was carried out as part of the activities of the Meeting of Exact Sciences and Technology promoted by PUC-SP. The short course was given in five days - from October 17 to 21, 2016 - in a 2-hour period, totaling the 10-hour workload.

The activity consisted of 17 participants, from civil engineering, production and biomedical courses, and it was founded as a playful exercise, with the objective of stimulating creativity and the ability to implement innovative ideas, through the articulation of concepts engineering theorists with the practice of object prototyping. The prototypes had a free theme but should create improvements in objects inspired by solutions of nature and should be developed within 5 days of the course, through teamwork.

The first day was the presentation in which the current demands of the labor market for engineers linked to innovation and sustainability were discussed. From this preamble the biomimetic methodologies were presented, with several examples of applications for engineering, and CDIO, according to which students should create prototypes of objects with a theme of their choice, preferably in groups formed by students from different areas, passing through the design, design, implementation and operation stages for each of the following days of the short course.

On the second day, focused on conceiving, Design Thinking tools were presented to aid the creative process. Then the discussion was opened for groups to present their ideas. Both professors and students from other groups made proposals to improve themes, or even suggestions on how to carry out the elaboration of projects and prototypes.

At the design stage held on the third day, students performed preliminary prototype designs during the course. They worked at simplified drawings in programs such as AutoCAD, SolidWorks, or Arduino simulators. The students listed the materials needed for the elaboration of the prototypes. Preferably, students should adopt inexpensive and accessible materials in order to favor the elaboration of the prototypes.

In the implementation stage carried out on the fourth day, the students made the assembly of their prototypes, counting on technical advice from the professors. At this stage, improvements in prototypes, simplifications or changes of materials and shapes were made in order to make the final operation feasible.

Finally, on the last day intended for the operation of the prototypes, the groups performed the presentation of their prototypes for all participants. The prototypes presented were:

- **Catenary Bridge**: prototype of an arched bridge using two inspirations: the catenary curve and the birds' nests;
- **Orthosis inspired by the gecko's leg**: hand bracing inspired by the grip of the gecko's paw for people who are difficult to hold objects due to diseases such as strokes or Parkinson's.
- **Slope contention with spider web-inspired mesh**: Development of a slope containment mesh inspired by spider web geometry in order to reduce earth buoyancy efforts. The mesh could be used for temporary measure of containment, in the period immediately after the cutting of the earth, in which the retaining wall has not yet been constructed.
- **Echolocation to support visually impaired people crossing the street**: inspired by the echolocation of the bat, a mobile application for the visually impaired has been developed capable of sending an alert to the user, through data sent by frequency waves. When the user is located near the pedestrian traffic light, the application would indicate whethertheycould cross the street.

As a course with an innovative approach for PUC-SP's engineering students, several difficulties were initially faced. One of the main ones was the time available for structuring the projects, since the course had only five days of application and represented a disruption with the common teaching standards, which needs a pro-activity of the target audience.

Several new knowledge, including biomimicry, were acquired over the course of the short course; however, scarce time limited the possibilities for application expansion through the CDIO methodology. With a view to providing a more fertile and solid environment for the applications of biomimicry in engineering, a semester-elective course with 2 hours per week was proposed.

The focus of the course is to deepen students' contact and interactions with the biomimicry and engineering innovations that may occur with their use. Thus, one of the main limitations of the mini-course can be overcome, through weekly contact with students and a longer time to apply the CDIO methodology.

The first offer of the course takes place in the second half of 2017, practically one year after the offer of the short course, so that there was time to plan, approve and offer at the Faculty of Exact Sciences and Technology of PUC-SP. The course is linked to the Civil Engineering course, however, the students of other courses can also study it, similar to the one that occurred in the short course, which counted on teams formed by students of different engineering courses.

5 Conclusion

The objective of this work is to evaluate the central question: "Could the union of the CDIO and Biomimicry methodologies generate a transdisciplinary active learning approach capable of building theoretical knowledge applied in innovative and sustainable projects?" And from the experience of the short course, it was possible to test the validity of the union of the two CDIO and Biomimicry methodologies, obtaining the following evaluations as to their pertinence:

By adding biomimicry to the CDIO methodology, in fact, there was an expansion of the students' project horizon, not only for the search for greater effectiveness and efficiency of the prototypes through solutions tested by nature, but also for raising awareness of the importance of sustainability in product life cycle and in the production process.

The marathon of prototypes carried out in a very short time period brought severe limitations as to the time for research and deepening of theoretical concepts of engineering and biomimicry. Moreover, the possibility of prototype improvements through testing or even the prototyping itself was compromised for the short term. On the other hand, despite these limitations the short course contributed to the development of the ability to work with limited resources and in short periods, recurring events in the professional life.

Even with the help of tools like the "Ask nature" site and access to a repertoire of examples of projects exhibited by professors, the analysis of natural solutions presented constraints: the lack of knowledge in the field of biological sciences by students and professors of engineering has also restricted the possibilities for creating solutions inspired by nature.

For the evaluation of the course an anonymous survey was carried out with the participating students. Of the students 41% respondents, only 14% did not like the course with the justification of finding direct application in the job market for the subject. The others 86% liked the experience, but they point out as limitations the short term for the elaboration of the prototypes and the lack of access to materials and technologies such as 3D printing for prototyping.

From this first experience an optional discipline was created in the Civil Engineering course of PUC-SP, whose name is "Biomimetic Engineering: innovation inspired by nature" in which the students would have 32 hours divided in 16 weeks to create the prototypes. The course is being offered for the first time in the second half of 2017 and the objective is to extend the deadline in which students can develop the projects and the application of CDIO and biomimicry in engineering. It is hoped that, through this initiative, new contributions will be generated in engineering education, which will be analyzed in future works.

In addition to the creation of the discipline, a second edition of the mini-course "Biomimicry: innovation inspired by nature" is scheduled to take place between October 23-27, 2017. Despite the maintenance of the short term (10 hours of course, as well as in the previous edition), this edition will have access to 3D printing technologies and a professor in the field of Biological Sciences to consult the projects in the initial periods of prototyping.

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Active methods in the teaching-learning process: a comparison of the application of meaningful learning in the teaching of logistics

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Abstract

The development of professionals to the Logistics area can be optimized with classes organized through Meaningful Learning Theory, developed by David Ausubel. According to this theory, the concepts and other propositions are learned through some others pre-existents concepts and, the new learning needs to be anchored to another existent content in the cognitive structure, so that it can be assimilated. This can be facilitated using some previous organizers characterized like general concepts that create anchor points to the more specific ones. In this study, with an exploratory character, this theory was applied in the reorganization of classes in a *Superior Course in Logistics Technology*. In one of the classes, in 2016 (experimental group), it was used previous memory organizers to identify if the learning results would be different when compared to traditional classes given in another group of students, also in 2016 (control group). To evaluate the introduced changes it was carried out an event to solve problems in a fast food store, where it was created the chaos in the customer service, so that the students could observe the operations in functioning, and after that, get through evaluating tests. In order to evaluate the knowledge, pre and post event tests were applied, and to compare the competences, it was hold the event in 2016 and measured the students' knowledge. In 2017, one year after, the activity was repeated, but without doing the event to solve problems in order to verify if there would be any significant difference in the results obtained in a new control group, but with the evaluated knowledge acquisition obtained using the same methodology from 2016. It was observed that the experimental group is still presenting higher results in relation to the control group, this confirms the importance of solving problems activities to consolidate the acquired knowledge. However, there are evidences the need for research on the methodology applied for the teaching of concepts tested before and after 2016

Keywords: Meaningful Learning; Teaching of Logistics; Agile Methods.

1 Introduction

It's known that globalization has reduced the borders to access consumer goods. However, it generated a huge demand of good logistics processes. This has also created a continuous search for specialized professionals in this area. The need of qualified labor boosted the creation of many colleges of Logistics Technology in all São Paulo State, that's why this discussion about how the learning process happens in these institutions is necessary.

The objective of this paper is the College of Logistics Technology in Guarulhos, São Paulo, mainly related to the integration of the content studied in the subjects Operational Research and Production Operation Management and the observation of this theory in practice.

The research goal is to measure the learning process and evaluate a possible improvement in the students' performance results with the adoption of an empirical experience. This happened in a fast food restaurant chain based in the same city of the college. There was another group analyzed one year after this first experience without applying the activity.

2 Scope

Promoting motivation to study is very important in the professional formation context through technological courses. In order to make this process easier, professors use teaching methods and technics, proper teaching materials for the contents they intend to teach.

It's essential to the learning process that the students have interaction with this process, with the teacher and with the colleagues. The studies about these processes started in the 1950's with the Cognitive Psychology studies, when it searched to study memory processes, attention, information withhold, learning and others. Among the researches done, some authors proposed to study teaching materials used in classes and what learning processes they triggered (Castaño, 1998).

Concerning to identify critical attributes of teaching methods and resources that affect the relevant learning cognitions, it was developed some learning theories able to recommend means to get specific teaching goals, like the Symbol Theory of Depiction, from Goodman, the Educational Theory Meaning from Olson and Media Attribute Theory from Salomon (Clark & Salomon, 1986).

One of the main expectations from these three theories was that the attributes identification can generate independent and genuine variables to the instructional theory, which would specify the causal relations among learning and attributes models (Castaño, 1998). Thus, rises a new attempt to search a connection between the means (in this case, the attributes) and the individual learning. However, it didn't happen. To Castaño (1998), no researcher could stablish any specific attribute of a single mean or a category of means necessary to learn some specific cognitive skill. Clark (1987) says that the media attributes are interchangeable and do not contribute, psychologically, to the learning process.

Therefore, the instructional materials need a proper instructional design to reach the desired goals. This design can be considered a presentation model of a certain instructional material, which is able to develop the competences and abilities that promote the knowledge building. This involves the knowledge of learning-teaching methodologies, educational processes, interactive tools and resources (Internet, CD-ROM, Videos, etc), all of them articulated with pedagogical and philosophical methodologies (LANGHI, 2015).

2.1 Meaninful Methodology

The meaningful learning theory was initially developed between the 1950's and the 1960's by the American psychologist David Ausubel who dedicated himself to carry out the studies about the learning processes in the classrooms. After he joined to Joseph D. Novak and Helen Hanesian and together they wrote the book Educational Psychologist, published for the first time in 1968 and reviewed in 1978.

According to this theory, the knowledge is organized in cognitive structures, or a set of knowledge that any individual have about a certain subject and the way that this background is related. The knowledge is distributed in the individual mind like general and wide ideas, and after they get integrated to more specific ideas.

The concepts and others propositions are learned through some others pre-existents concepts, which is called subsumption by Ausubel and cols. (1980) and means that a general concept is able to shelter a more specific concept. It is how the meaningful learning appears, in order to learn in a meaningful way, the individual must have a concept or a more general proposition inside, so that it's possible to connect the anchor points to a more specific knowledge. The subsumption became more absolute when it assimilates new information.

Each academic subject has an articulated and hierarchically organized conceptual structure that forms an information system of this subject *(Ausubel and cols., 1980). These structural concepts can be identified and* *taught to the students, forming something like an intellectual map that can be used to analyze some particular points of the subject and solve problems.*

Once these general and specifics concepts of the subject or set of knowledge are identified, they can be hierarchically disposed in a two-dimensional diagram used for instructional purposes. These diagrams are called "conceptual maps". The conceptual maps reflect the theoretical organization of a subject, or part of this subject, so its existence is derived from its own conceptual structure.

2.2 Previous memory organizers

Ausubel *et.al.* (1980) highlight the importance of preexistent cognitive structure and the meaningful organization of the subject to be taught as main concerns in the instructional planning. These two tenets will help to compose the instructional materials and the evaluation techniques. They emphasize indeed the importance of previous memory organizers in these materials.

The use of previous organizers is a strategy proposed to manipulate the cognitive structure in order to facilitate the meaningful learning. They consist in an introductory material with a higher level of abstraction and generalization of the new learning material. They are different from abstract or summaries, because they have very high level concepts, or even the contents macrostructure where the details were left out, but they aren't concepts of higher level than the new material, like it happens in the previous organizers.

These organizers can provide an "anchor idea", or, stablish relations among ideas, propositions and concepts that already exist in a cognitive structure and those enclosed in the learning material.

Thus, it's up to the previous organizers: a) identify the relevant content in the cognitive structure and clarify the relevance of this content to learn the new material; b) give a general view of the material in a high level of abstraction, pointing out the most important relations; c) provide organizational inclusive elements that take in consideration, more efficiently, and highlight the specific content of the new material. (MOREIRA, 2006)

For many reasons, the specific organizers, intentionally built to each one of the units to be taught, must be more effective than simple introductory comparisons between the new material and what the students already know. Their advantage is to allow the students the exploitation of subsumption characteristics, in other words, to identify the relevant content in the cognitive structure and explain the relevance of this content to learn the new material; to give a more general view in a higher level of abstraction enhancing the important connections; to provide organizational inclusive elements that take in consideration and highlight in an efficient way the specific content of the new material.

The organizers are more efficient when presented in the beginning of the learning tasks than when introduced simultaneously with the material to be learned, because in this way the integrating properties are highlighted. To be useful, it's necessary to draft these organizers in familiar terms to the students, so that they can be learned and they also need a good organization of the learning material to have pedagogical value. *(Barnes & Clawson, 1975)*

2.3 Learning evaluation principles and problems solution

To Ausubel et.al. (1980) the genuine comprehension of a concept or proposition implies the possession of clear, precise, distinguished and transferable meanings. However, when testing this knowledge only asking the student to say which attributes, logical criteria of a concept or the essential elements of a proposition, we can obtain only mechanical and memorized answers. They argue that a long experience in doing exams make the students get used to memorize not only propositions and formula, but also causes, examples, explanations and ways to solve "typical problems". So they propose that, when searching for the meaningful comprehensive evidence, the best way to avoid the "meaningful learning simulation" is to use questions and problems that are emerging, not familiar ones and that request the maximum transformation of the existent knowledge.

When referring to the learning process in the classroom, Ausubel et.al. (1980) emphasize the importance of: a) measure the comprehension of the key concepts in each subject; b) pre and post-testing in long term, and also simultaneously and immediate post-testing; c) learning for a field; d) indirectly test the knowledge of a previous learning when measuring the capacity to learn a consecutive depending material; e) trust more in potential tests than in agility tests.

The problem solution can be considered one of the most effective ways to evaluate if there was transference in a meaningful learning process. On the other hand, create tasks involving problems solutions and evaluate them it's not a simple work.

One of the most acceptable definitions among the cognitive researchers about what can be considered a problem is the accurate observation of an existent situation that contains an objective to re reached, whose ways to solve it are not entirely clear (Sternberg, 2000).

There are different engineer training models in Europe and from these models others were adapted in others part of the world (Linda Gardelle, 2017). In this context, to understand the model adopted by the college where the research was developed, it is good to know that on the first semester the students learning about logistics fundamentals; On the second semester of the course the students attend to the subject of Quality and they learn the main quality concepts, applications and tools to evaluate and correct process; on the third semester they have the subjects: Production and Operation Management and Operational Research, where they learn controlling concepts, organization and tools and production management; at last, on the fifth semester, they attend to the subject of Supply Chain Management, to learn supply chain concepts, demand management, production flow, customer service and stock inventory.

3 Methods

The learning evaluation process and assimilation was performed in 2017 with a group from the 5th semester (from a total of six semesters) of the Logistics Course in a Technological College.

The activity is developed in a North American fast food restaurant that presents an excellent system of production, quality and flow control; it consist of going to the store with approximately 40 students and all of them make an order of the same product (a product with low demand) and cause a situation that is not predicted on the sales forecast, and with this action they create a collapse in the productive system.

It's in this rich environment that the active learning process happens, according to Grabinger e Dunlap (1995) the appropriate environment to the active learning must promote the study and the research in an authentic context, it also must promote the responsibility, the initiative, the decision making, the intentional learning and the collaboration between teachers and students, encouraging a dynamic and interdisciplinary activity. This environment fosters the systemic thinking and also allows the students to develop complex and rich knowledge structures inside a realistic context of practical activities.

In face of this collapse, the students are requested to observe all the problems presented in the situation and with the knowledge they acquired in the subjects studied during the course, they can identify these problems and find possible solutions.

To perform the event in the fast food store in 2016, the convenience sample relied on a student's selection, considering that they had already had the opportunity to know the concepts involved in the experiment, which were acquired through traditional methodology, or expository teaching.

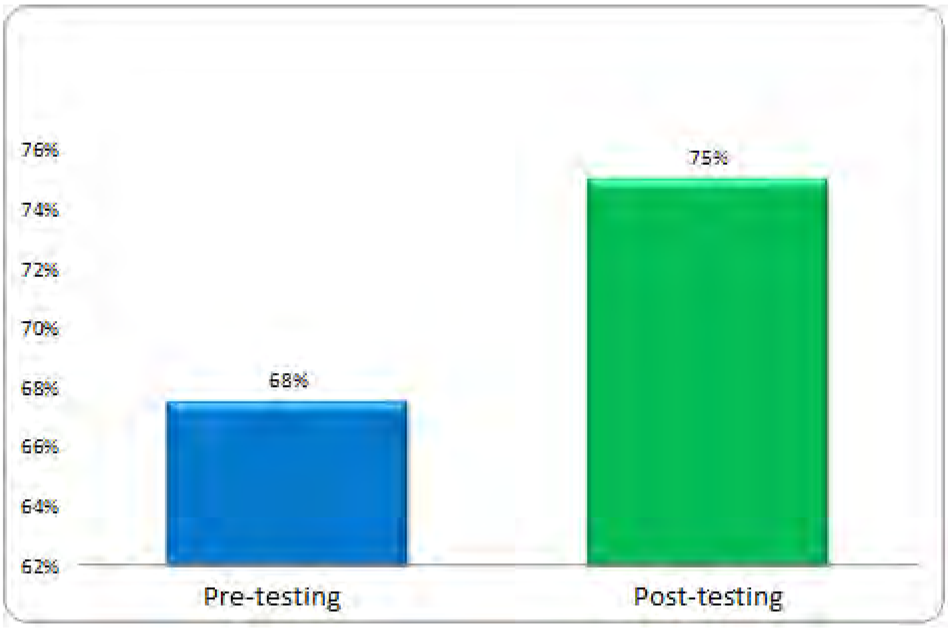
Using the study case method, the course aspects and the subjects were analyzed and the students were asked to observe how the main concepts were applied in the chosen fast food restaurant, especially in relation to the theory of queues in order to verify what happens with a logistic system when the arrival rate (ʎ) increases without increasing the average number of consumers (µ); and the theory of constraints concept in the production operations, with the objective to observe the basic impact between push and pull operations, considering that the productive flow is controlled by the supplier in the push operations and by the customer in the pull operations.

In 2016, before going to the event, in order to identify if the students could remember the main concepts, they did a pre-test containing fifteen multiple-choice questions with high difficult level. One day after the event, it was applied a post-test with the same questions from the pre-test, but with the alternative order inverted, to avoid the perception that they were doing the same test. Ten days after participating in the event, the students did an activity to solve a problem with a single and specific question that involved applying the concepts learned in class and also their application in practice in a business environment. This situation was analyzed by independent evaluators. They examined the existence of the main concepts that should be analyzed during the observation performance in the empirical experience (happened in the fast food restaurant).

4 Results

The result obtained in 2016 by multiple-choice tests through pre and post-testing is presented in the Figure 1 using relative values according to the criteria applied to define the sample population involved in the teaching-learning process studied.

Figure 1 Grades obtained before and after the activity



The results were obtained through the evaluation of specific questions answered before and after the experiment and only with the students that participated in the activity.

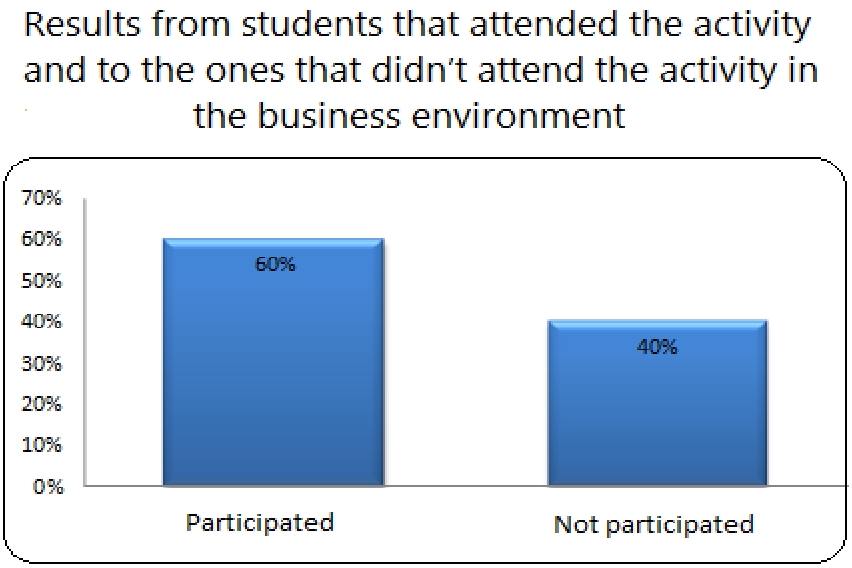
As it's possible to check, the result obtained after the participating in the activity reveals a significant improvement in the accuracy rate. This confirms that the empirical experiment contributes to measure the teaching-learning process and also to evaluate the knowledge transfer that was possible with the support of the Meaningful Learning. This theory states that the students acquire a huge part of their knowledge through meaningful and significant learning that can be facilitated by the traditional and expository methodology used in classes and also a proper instructional material, in this study it is presented by the experiment.

In 2016, to evaluate the learning process using the problem solution, it was proposed the following situation to the students that attended the activity and to the ones that didn't attend the activity in the business environment:

"As a logistics professional you were hired to work in a big multinational fast food restaurant chain. As soon as you start the job, you realize that there is a big problem in one of the restaurants. Sometimes some unusual situations happen and a certain amount of people create a high demand of a specific item and this affects the whole system operation. What actions do you propose to maintain or to recover the good system performance?"

Analyzing the students' answers after ten days of the activity, it was collected the results as shown in Figure 2

Figure 2 Index of correct answers considering the relationship of the answer given with the application of the concepts in practice

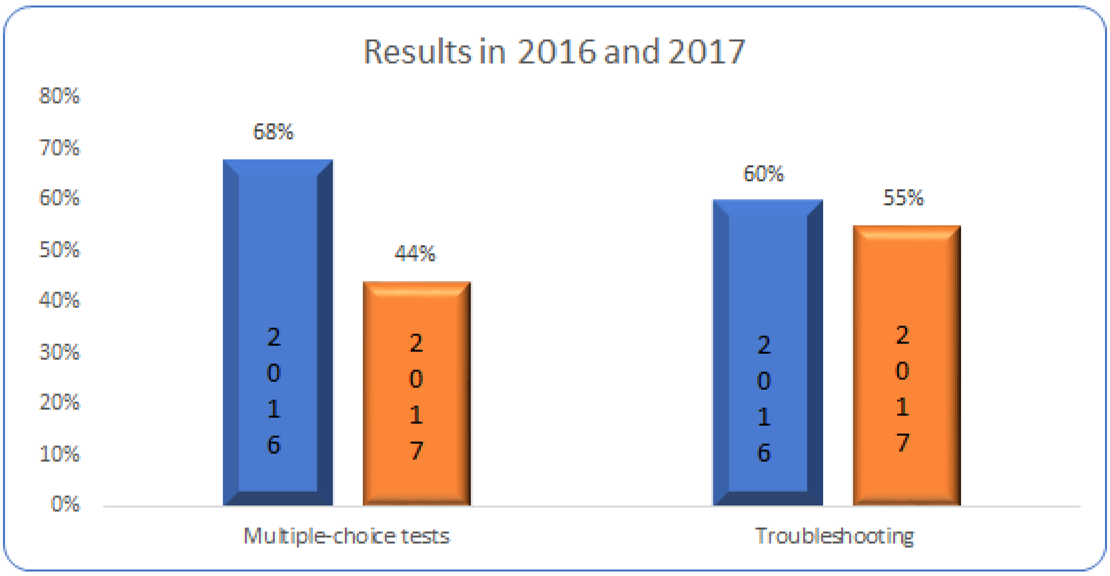


In this specific case, because the answers were free, it was tried to identify the relationship between the concepts involving the queue theory and the constraints theory in the production operations since the students caused an unusual queue formation during the experiment, because they all arrived at the same time, they also cause a breakdown in the capacity to attend the customer in the production operations inside the restaurant (because they all made the same order request).

It was noticed that the students who attended the activity got a result 20% better than the students that answered the same problem situation without attending the empirical experiment.

In 2017 the activity in the business environment was not performed, so it was done only multiple-choice tests and the proposal to solve a problem with the same contents applied to the experimental and control group in 2016. The results collected are presented in Figure 3 and were obtained by a single control group in 2017.

Figure 3 Results obtained without activity in the business environment



As it's possible to see in figure 3, the results obtained in 2017 compared to those of 2016 show that there was a significant difference in the results of the multiple-choice tests among students who did not participate in the business environment and a difference of only 5% in the problem resolution among students who participated in 2016 in relation to those of 2017, who did not participate.

Thus, it's possible to infer that, with the accomplishment of experiments that allow the verification of the application of concepts learned in the classroom in a business environment, although in a small part it can contribute to the consolidation of the teaching and learning process. And, on the other hand, the comparison of the results of the multiple-choice tests evidences the need for research on the applied methodology for teaching the concepts tested before and after 2016

5 Conclusion

Considering that the objective of the empirical experiment in 2016 was to measure the learning process and to evaluate a possible improvement in the students' performance results and that in 2017 was tried to verify if there were substantial differences in the obtained results by another group, with the acquisition of the evaluated knowledge was obtained by the same methodology of the 2016 group.

It was verified that, by the 2016 experiment, the application of adequate instructional material aligned to the significant learning allows evidence of perceptual improvements provided by the proper application of methodologies that allow the comparison between acquisition and retention of knowledge by students who participate in a practical activity with those who do not experience solution problems, which is true for both the 2016 and 2017 control groups, in the business environment, which is the object of study in the classroom.

However, comparing the results of the multiple-choice tests of 2016 with those of 2017 evidences the need for research on the methodology applied for the teaching of concepts tested before and after 2016, since it was considered the same but apparently negated by the results.

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Teaching Economics to Engineering Students: results of a flipped classroom experience

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Abstract

Teaching Economics at technical universities is a big challenge. There are studies that identified that Economics is one of the least popular disciplines due to the complexity of materials and the uninteresting long lectures. This paper shows a successful experience in teaching Economics to engineering students. A question guided this study: How can flipped classroom strategy influence the motivation to pre-class study, the perception of learning and the development of soft skills in the context of Economic classes to engineering students? An online questionnaire was answered by 23% of the students that took classes of Economics at a Brazilian university in the first semester of 2017. Considering the analyzed data: a) 75% of the students engaged in the pre-class activities; b) 81% of the students said that they felt themselves responsible for their own learning and c) 96% said that the professor was effective to direct the learning process. It was asked what motivated them to pre-class study: a) 86% said yes to the teacher´s orientation, b) 81% said yes to pre-class concept tests, c) 70% said yes to seminars and d) 67% to pre-class available material. About the aspects that facilitated the understanding of the content: a) 95% said yes to the pre-class available material, b) 91% said yes to in class activities, c) 88% said yes to the teacher´s orientation, d) 73% said yes to the preparation of seminars and e) 70% said yes to colleagues interaction and seminars presentation. Besides that, 91% of the students declared that this method improved the quality of their learning. Yet, 73% percent of the students said that their soft skills were developed (eg. communication, teamwork, autonomy and creativity). This study shows that the flipped classroom approach engages students turning a non technical discipline into an interesting journey.

Keywords: flipped classroom, teaching economics, pre-class studying.

1 Introduction

Economics is one of the mandatory disciplines of Brazilian Engineering Courses. Every Brazilian Engineering student will have the opportunity to study macroeconomic and microeconomic concepts that varies from large-scale or general economic factors to individual decisions and its impacts (RESOLUÇÃO CNE/CES 11, 2002). This is one of several other social science body of knowledge that will help the formation of an engineer that is not only effective as a technical professional but is open minded to understand the implications of his or her work to the society.

Hayford (1917) discussed about the importance of the study of Economics to engineering students. He said that it is important to develop a social conscience in the student of Engineering by forcing the students to think in terms of groups of people. He stated that economics effectively taught will help the Engineering student to see the real ultimate purpose of Engineering and help in inspiring the students to great social achievements.

As Hayford (1917) noticed, a great engineer will see beyond the technique. When he or she design a mechanical or electronic project, the elements that determine the performance of this invention are the increase of productivity, the improvement of human quality of life and other impacts that are all economic factors. When an Engineering student understand the economic implication of his work, the inspiration makes the difference between the great engineer and the mere engineer (Hayford, 1917).

That importance of Economics in the Engineering Education context and the fact that it is one of the least popular disciplines in terms of student feedback on teaching (Becker & Watts, 1998) motivated this study. This paper shows the impacts that an innovative pedagogical approach can generate in the teaching of Economics to Engineering students. The flipped classroom was elected as the active learning strategy to teach Economics to Engineering students at the Federal University of Itajubá - Itabira campus during the semesters of 2016 and 2017.

A survey was developed with the students who attended this discipline and it was possible to understand its impacts in terms of the motivation to pre-class study, the perception of learning, the development of soft skills and the instructor's effectiveness. To discuss these results, this paper was organized into 6 parts including this introduction. The second part presents the theoretical framework that indicates the challenges and alternatives to turn the teaching of Economics an interesting journey to Engineering students and the ultimate considerations about flipped classroom. The third part is the description of the research procedures. In the forth part the data discussion is presented. The fifth part is the final consideration of the research. In the final part, the references are included.

2 Theorical Framework

2.1 Teaching Economics to Engineering students: challenges and alternatives

According to Hayford (1917) the study of Economics is crucial to Engineering students because it develops a social conscience by forcing the students to think in terms of a society. One of the purposes of this discipline is to open the students mind in order to help them to perceive the economics implications of the Engineering projects and inventions. Therefore, Economics tends to lead the Engineering student to the broader view that in turn gives the inspiration which produces the steady motive power that will drive the future engineer through discouragements and obstacles to achievements that are worthwhile (Hayford, 1917).

Despite the importance of Economics to Engineering students, an American research published by Becker and Watts (1998) indicated Economics among the least popular disciplines in terms of student feedback on teaching. These authors noticed that by the 1990s, while many other disciplines had introduced much more variety and interactivity into teaching, Economics remained wedded to lectures, supported by limited audiovisual input, with textbooks and possibly workbooks as the staple. This reality can be taken for granted in the Brazilian case since the majority of courses are taught in the traditional style of long lectures and no significant learning and teaching experiences.

Barnett (2009) claimed that lecturing is used extensively in most Economics programs which has generated much complain among students. According to her, there are three main areas where students felt economic lecturers need to improve their practice: structuring, reducing the complexity of visual materials, and making lectures more interesting. On these subjects, Barnett (2009) points some strategies to turn economic teaching more effective.

First, she suggests that each lecture must start with the 'big picture' showing the particular steps to be achieved in a broader context, and then links back to the step already covered, and forward to the next. Second, the lecturer must ensure that his or her PowerPoint or similar presentation is suitable for the key features of effective visuals in economics, which are simplicity, accuracy and flexibility. And third, the instructor must add technological and interactional experiences to help students to understand the contents and do not just seat and listen a long boring lecture.

Lait and Birdi (2014) presented a variety of active learning strategies that has been used to recast the traditional economic lecture. One of the strategies is to use appropriated technologies to provide a just in time learning experience (Mazur & Watkins, 2010). The use of clickers or other classroom response systems (including polling software or applications on personal devices) allows students to individually and/or anonymously interact which can even be done through a gaming atmosphere turning the experience must more attractive.

Other strategy mentioned by Lait and Birdi (2014) is the lecture capture and its availability on line. This technology, now widely available in many universities, enables the recording of lectures and make them available to students online, usually via a virtual learning environment. The benefits of lecture capture are various because students can catch up on classes they miss, they can review the lectures anytime and anywhere, they can stop anytime they need to take notes and they can tailor their learning experience as they want.

A world-wide strategy called flipped classroom is mentioned by Lait and Birdi (2014) as well. According to them, in flipped classrooms, students are first exposed to subject material before the lecture (often through short videos and readings) so that class time can be used more effectively for student learning. The idea is that students cannot sit passively in the class, but instead must use this time to engage in activities that are often considered part of their independent study or homework, such as problem solving, applying what they have learnt and working with peers (Berrett, 2012). As a central active learning strategy analyzed in this paper, the next session will be devoted to its better description.

2.2 Flipped Classroom

As a movement of innovation of the learning process, several technological applications has been created to improve the learning process. As mention above, response systems has been used to provide just in time teaching in which students can interact with knowledge and teachers can tailor their lectures according to instantaneous student feedback. Besides that, the on line education has been spread all around the world which brought important platforms such as Khan Academy founded the in 2006, by Salman Khan a MIT alum, Udacity, which hosts information technology courses with more than seven thousand students on line and Coursera, which is considered one of the most valuable education technology startup in the world. All these platforms are examples that recent technologies are reshaping the education experience in present time.

The flipped classroom is one of the active learning strategies that are using the technology trends to improve the learning process. Bergermann and Sams (2016) started to use this method in the high school context. They are Chemistry teachers that joined, in the 2003´s, to record their own lectures and to provide them in the internet. Their purpose was became the in class time more effective with interactive learning activities instead of wasting this time with lectures that students passively listened.

According to Bishop and Verleger (2013), the flipped classroom is a new pedagogical method, which employs asynchronous video lectures and practice problems as homework, and active, group-based problem solving activities in the classroom. For these authors, it represents a unique combination of learning theories once thought to be incompatible-active, problem-based learning activities founded upon a constructivist ideology and instructional lectures derived from direct instruction methods founded upon behaviorist principles.

Bishop & Verleger (2013) noticed that there is a lack of consensus on what exactly the flipped classroom is, and there is also a limited amount of scholarly research on its effectiveness. These authors define the flipped classroom as an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom. They restrict this definition to exclude designs that do not employ videos as an outside of the classroom activity. On the other hand, there is a broad conception of the flipped classroom as the assigning readings outside of class and having discussions in class. Both views are found in the literature but the first one is more effective (Lait & Birdi, 2014); Berrett, 2012; Bishop & Verleger, 2013).

Most important on this strategy is that the evolution of flipped classroom has replaced the old method of teaching pedagogy such that teachers role is changed from being *"sage on the stage" to "guide on the side"* in the conventional and flipped classrooms respectively. This concept can be illustrated in the figure 1 below. From the diagram, the teacher took the centre stage in the class and the bulk of activities revolves round the instructor (Ajayi, Iahad, Ahmad & Yusof 2017).

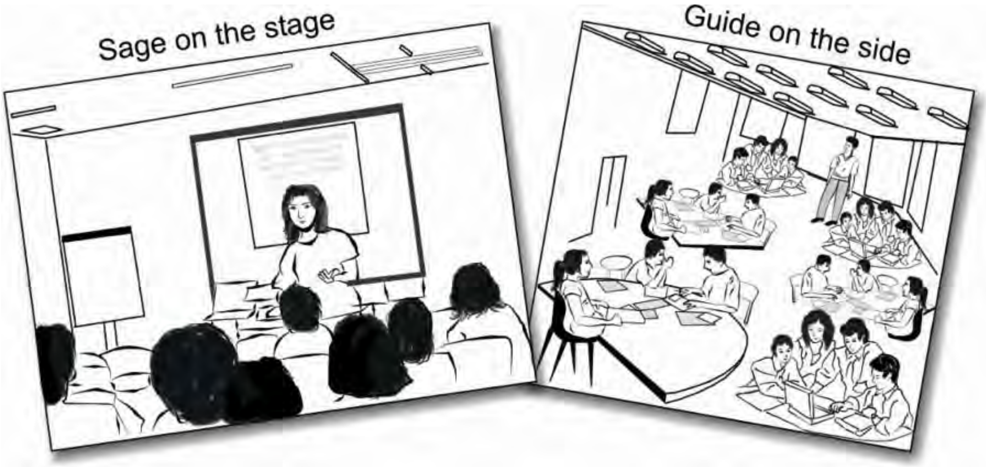

Figure 22. Illustration of transformation of traditional face to face teaching method to flipped classroom. Source: http://www.eit.edu.au/creating-useful-education-and-training

The implications of this change from traditional style to the flipped classroom procedure is that there is the inversion of several aspects: a) the teacher role: from the only speaker to the facilitator of students participation; b) the student role: from a passive content receiver to an active knowledge builder; c) the time of study: from pre-test study to pre-class study; d) the forms of assessment: from exclusively summative to partially formative and summative; e) the objectives of learning process: from exclusively technical to partially technical and behavioural as well.

3 Research Procedures

This is a descriptive research (Gonçalves & Meirelles, 2002) which is the most appropriate modality to describe the impacts of flipped classroom strategy in terms of the motivation to pre-class study, the perception of learning, the development of soft skills and the instructor's effectiveness. In order to know in depth the results of the activities performed, the quantitative strategy was used that according to Gonçalves and Meirelles (2002) is more adequate for the quantification and analysis of the behavior of a given population.

To achieve the objectives of the study, a case study was developed that, as Yin (2005) states, can be useful for testing theories and elucidating situations. The case studied was the pedagogical experience of teaching Economics to Engineering students at the Federal University of Itajubá - campus of Itabira. In this case the flipped classroom was used with the objective of enhance learning results in terms of the motivation to pre-class study, the perception of learning and the development of soft skills.

Data collection was done through the application of an online questionnaire that was answered by the 23% of the students of the discipline at the end of the course. The questionnaire was composed of 23 closed questions that students were asked to answer on a 5-point scale that indicated how often the situations in the questions occurred, being 1 for never, 2 for rarely, 3 for some times, 4 for most of the times and 5 always. Thus, four sets of questions were raised which were: a) motivation to pre-class study generated by the handled material, the concept tests available before the classes, the instructor's orientation, the seminar preparation and the seminar presentation; b) perception of facilitation of understanding provided by the handle material, the in class activities, the interaction with colleagues, the instructor's orientation, the seminar preparation and the seminar presentation; c) perception of development of soft skills (communication, teamwork, autonomy and creativity) and d) perception of the instructor´s effectiveness. At the end of the questionnaire there was an open space to the students leave suggestions and comments that was useful to qualitatively analyze the experience. For data analysis, descriptive statistics were used to determine the percentage of students that fit into each situation described in the questions.

3.1 Description of the activities developed in the discipline

The discipline Economics is part of the curriculum of the undergraduate courses in the 9 Engineering Courses available at the University of Itajubá - campus of Itabira. The discipline consists of 48 semester hours. The main objective of the course was to offer concepts of Economics in order to let students understand the economic national and international context. At the begging of the semester, the teacher explained the objectives and teaching procedures of the discipline (strategies, activities and assessment procedures). The teacher showed to students how the flipped classroom would occur with pre-class study, pre-class concept tests and in class activities. The discipline was divided into 7 modules (Concepts of Economics, Economic Principles, Gross Domestic Product, Inflation, Fiscal Policy, Monetary Policy and Cambial Policy). Each module was delivered during 2 classes.

In each module the process showed below was conducted (Table 1)

Table 13. Phases and Process of flipped classroom used in the discipline

Phase	Process	When it occurs
Pre-class study	For each module the student was asked to read the handle texts that was available at the educational plataform of the university	Before Class 1
Pre-class concept test	After reading the handled material, the students were asked to solve a concept test that was available at Google forms	Before Class 1
In class check of concept test	At the begging of the class, the teacher showed the statistics of each question of the concept test giving emphasis to questions with less than 75% correct.	During Class 1
Application Exercises	A variety of application Exercises was provided in each module such as Analisys and Group Discussion about economic Brazilian indicators, Case Studies comparating Foreign Countries, Group Dynamics	During Class 2

At this experience, the pre-class study was made using only texts about the subjects of each modules. These material was composed by texts books and current news related to each subject. After his phase, the students solved the pre-class concept tests. 75% of the students engaged in this activity, even though the teacher gave credits to whom that solved the concept tests. Solving the concept tests plus participating in class activities summed 20% of total grade. Seminars corresponded to 20% of total grade. And the meddle term and the final term corresponded to 60% of total grade.

During the phase "in class check of concept tests", students had the opportunity to clarify any aspects they thought it was necessary. This phase was often conducted under intense interaction between teacher and students. The application exercises had the objective of letting students to apply the concepts previously studied. Every application exercise was experienced in groups and ended with a general presentation of the discussions to all classmates.

Besides the flipped classroom dynamics presented above, the students were organized in groups in order to prepare and to present a seminar that was delivered at the end of the semester. Besides this group activity, every application exercises was discussed in groups.

3.2 Presentation of collected data

As we pointed on the previous session, the students were asked to answer the questions on a 5-point scale that indicated how often the situations in the questions occurred, being 1 for never, 2 for rarely, 3 for some times, 4 for most of the times and 5 always. Considering the most frequent situations (responses 4 and 5) we got the results presented on Tables 2, 3, 4, 5 and 6 which are considered the assessment level of the aspects the research focused.

As can be noticed in Table 2, 86% of the students said that the instructor´s orientation motivated them to pre-class study. Near this assessment level, concept tests which was a pre-class activity deliver before each module, was effective to motivate 81% of the students. The seminar preparation and presentation had a lower influence to motivate the students to pre-class study, with 70% of positive answers. The handle material had the lowest evaluation. Only 67% said that the material motivated them to pre-class study.

Table 2. Motivation to pre-class study

Situation	%
The instructor's orientation motivated me to pre-class study	86%
The concept tests available before the classes motivated me to pre-class study	81%
The seminar preparation motivated me to pre-class study	70%
The seminar presentation motivated me to pre-class study	70%
The handled material motivated me to pre-class study	67%

Table 3 presents the perception of facilitation of understanding provided by some aspects. The great majority of the students agreed that the handled material (95%) and in class activities (91%) facilitated their understanding of the content. The instructor's orientation was well evaluated as well, with 88%. The other aspects had lower levels since 77% of the students said that the preparation of the seminars facilitated their understanding. Yet, 70% of students reported that the interaction with colleagues and the seminar presentation facilitated their understanding.

Table 3. Perception of facilitation of understanding

Situation	%
The handled material facilitated my understanding of the content	95%
The in class activities facilitated my understanding of the content	91%
The instructor's orientation facilitated my understanding of the content	88%
The seminar preparation facilitated my understanding of the content	77%
The interaction with colleagues facilitated my understanding of the content	70%
The seminar presentation facilitated my understanding of the content	70%

Table 4 presents the perception of development of soft skills. 74% of the students reported that the method provided the development of communication, teamwork and autonomy. Yet, 63% of the students said they perceived that their creativity skill was developed. Probably, the incentives provided by the method can be improved in order to make this development of skill more intense. Providing more activities in which these skills can be enriched.

Table 4. Perception of development of soft skills

Situation	%
The adopted method provided the development of my communication skill	74%
The adopted method provided the development of my teamwork skill	74%
The adopted method provided the development of my autonomy	74%
The adopted method provided the development of my creativity skill	63%

As can be noticed in Table 5, the perception of effectiveness of instructor's ability and skills got the highest assessment level. According to the answers, it is possible to see that the instructor was effective to guide the learning process and to propose relevant reflections to the learning process in the opinion of 98% of the students. According to 95% of the students, the instructor of effective to engage and to motivate the students to study. Yet, 93% of the students reported that instructor was effective to motivate creative and innovative behavior.

Table 5. Perception of instructor's effectiveness

Situation	%
The instructor's professional experience was enough to guide the learning process	98%
The instructor was effective to propose relevant reflections to the learning process	98%
The instructor was effective to turn the learning process into engaging process	95%
The instructor was effective to motivate me to study	95%
The instructor was effective to motivate me to act in an creative and innovative manner	93%

With regard to the pedagogical approach (flipped classroom), it is considered that the experience was well evaluated. According to 98% the students, the content of the discipline was fully learned. Regarding the essential purpose of active learning strategies, to enable the student to be permanently active in the learning process, it was reported that 81% of the students felt responsible for their learning. Besides that, 91% of the students declared that this method improved the quality of their learning. Regardless all the good aspects presented above, it is considered that some improvements are needed in order to turn flipped classroom even more effective in teaching Economics to Engineering students. It will be discussed in the next session.

4 Data Discussion

The question that guided the study was: How can flipped classroom strategy influence the motivation to pre-class study, the perception of learning and the development of soft skills?

In general, the application of the active learning strategy flipped classroom had positive impacts on students' learning, which engaged in pre-class studying. As presented previously, the great majority of students reported that the content of the discipline was fully learned, they felt themselves responsible for their learning and they declared that this method improved the quality of their learning.

Regarding the motivation to pre-class study there is a space for improvement related to the handled material. As a lower portion of students reported that it motivated them to pre-class study, it can be considered that it was not sufficiently interesting to motivate students to pre-class study. At the suggestion field of the questionnaire, some students reported that the material was very complex and extensive with little relation to real life context. To solve this problem, it would be important choose or adapt the texts using a colloquial language and clear examples related to the actual economic facts.

Curiously, the handled material was the most important aspect that helped students to understand the content. As the version of flipped classroom did not used videos at pre-class study, probably it could have an important role in the learning process, as the literature indicates (Lait & Birdi, 2014); Berrett, 2012; Bishop & Verleger, 2013). It is believed that the essential benefit of flipped classroom was achieved. Students was engaged in pre-class studying and in-class activities had an important role to easy the learning process.

It is believed that some changes are needed to help students to develop their soft skills. Probably, at in class activities it is possible to challenge students to improve their professional profile. Some students suggested that there were more presentation and opportunity to develop their communication abilities. It is going to be useful if direct directions about the development of these skills is provided at the begging of the course with formative assessment about these aspects.

The effectiveness of the instructor was very well evaluated. Although at active learning strategy the student is the center, instructor have an important role to direct students during the process. Notice that, besides the effectiveness of the instructor to lead the learning process, instructor´s orientation was important to motivate students to pre-class studying.

Data showed that this pedagogical experience was good enough to help students to learn a very important knowledge that can open their minds as engineers and business professionals. We also notice, by this research, that the class was effective flipped considering the aspects mentioned at the literature: a) the teacher facilitated students participation; b) the student was an active knowledge builder; c) the pre-class study occurred; d) the forms of assessment was formative and summative and the objectives of learning process was technical and behavioural as well.

5 Final Consideration

It can be said that the learning process was more effective using the flipped classroom strategy to teach Economics in Engineering courses. One of the points that attracted attention was that student reported they felt themselves responsible for their own learning. It was noted that the method used turned the learning of a non technical discipline more interesting to students.

Although teachers' skills have been well evaluated, it is understood that teachers should constantly seek the updating of techniques and mechanisms to improve the sharing of knowledge with students. Another important aspect to be considered in future experiments is the inclusion of videos in the handle materials. This tactic would facilitate the understand of the content.

As possibilities of future studies, we aim to compare results between disciplines, the expansion of this research for the whole campus besides a research with graduates of the university to verify the impact of the disciplines in the life-long learning.

This study showed the importance of the facilitator's role in learning process. Flipped Classroom approach proved its value to engage students and turned the learning of Economics into an journey full of significance to the students. It was possible to point out opportunities for improvement: include videos in the handle material, provide more interesting texts, deliver clear directions about the development of soft skills and tailor in class activities that challenge students to use communication, autonomy, teamwork and creativity skills.

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Continuous Integrated Team Learning

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Abstract

Continuous integration is a project development practice, used in software development, that encourages developers to communicate and collaborate by merging their code improvements into a shared version control repository after every progress. Every change in the project is immediately tested and reported to the entire team.

Combining continuous integration and project based learning strategies allows a large group of students to plan their project together, and keep team members aware of project progress at any time, enabling them to test hypothesis and discuss with colleagues and also receive constant and immediate feedback from an automatic test procedure, as well from other team members.

Agile development strategies, were used for general project development. In a planning meeting students discuss, during class time, strategies for developing the project requirements, and just after this meeting they start implementing the project. Then every week, students have a sprint assignment, which a cloud computing continuous integration infrastructure is available for implementing planned tasks. Unit tests and system tests are supplied at the sprint beginning by the instructor, supporting students to know their progress correctness instantaneously. Review and retrospective meetings are conducted by students at the end of sprint.

This approach leads to teamwork cognitive and non-cognitive skills development, since students have to interact with their colleagues constantly in order to understand and develop in an ongoing project. An online Kanban board is shared by students, supporting them to organize their sprint.

A computer engineering course about building and entire computer from basic hardware to sophisticated software was used as study case for this proposal. In a first moment, the pedagogical strategy developed limits the project autonomy, since the automatic integration and test procedures demand some prior project organization, but as the project evolve and students get more comfortable with the infrastructure, they start to develop their own tests and they shape the projects the way they decide.

Keywords: Project Based Learning; Teamwork; Continuous Integration; Agile Development; Formative assessment.

1 Introduction

The process of ensuring that someone is learning something is traditionally achieved through summative assessments applied by teachers in scheduled class periods, which leads to a high-stake evaluation process with students only being aware of their learning status lately, sometimes after the end of the course term. Formative assessment is an alternative strategy, where the goal is to provide ongoing feedback through a low-stake evaluation process, quickly showing students their strengths and weaknesses, improving their learning experience (Shute, 2008).

The fast and constant feedback required by formative assessment may become impracticable for a professor working without proper support, specially in a project based learning course (Adderley et al., 1975) with students being organized in larger groups. The strategy presented to overcome that is based on Continuous Integration practices (M. Shahin et al., 2017), which comes from the computer development industry. Continuous Integration is a technique used for project development were programmers can submit their code implementation to a shared repository, where a software service checks submitted file changes automatically, enabling developers to evaluate the correctness of their submission continuously. This technique also easy team work, since every step in the project is shared among the group, and possible detected problems can be quickly detected and solved. This strategy could be also applied with geographically distributed teams, where distant people can easily contribute and discuss their development with others.

As continuous integration was used for educational purposes, time in classroom was maximised for face-to-face discussions, avoiding wasting time with additional assessments. This increased planning time spent by students, allowing them to better understand project and learning goals. They could better identify the necessary achievement since the process to validate their delivery was created presented before they start to work. This also lead to better integration among students, since students with higher levels of expertise and efficiency could support other students.

Among the complementary strategies, flipped-classroom was used with student, letting them to get prepared before class by seeing video and answering online quizzes at home, assuring a more efficient time for discussion in classroom, since every student is in the same page. Using these strategies, students could have available a preliminary low-stake assessment, like quizzes as they read the preparation material for class, allowing them to resubmit answers many times they want. An additional goal was to contextualize students with the computer science evolution, enabling them to better understand some past decisions and to take better decision in the future.

These strategies were applied in a basic computer engineering course were students are expected to develop an entire computer from transistors. This course used as reference the book "The Elements of Computing Systems: Building a Modern Computer from First Principles" by (Nisan, & Schocken, 2005). The pedagogical strategy is divided in two main blocks: an electronic block where students are expected to create hardware using hardware description languages; and a software block where object oriented languages are used. The local implementation of this course is part of an undergrad program oriented for a hands-on experience in project based group learning (Soares, Achurra, & Orfali, 2016). Figure 1 synthetized all support student has during the course, including: online material, continuous integration, group and individual help.

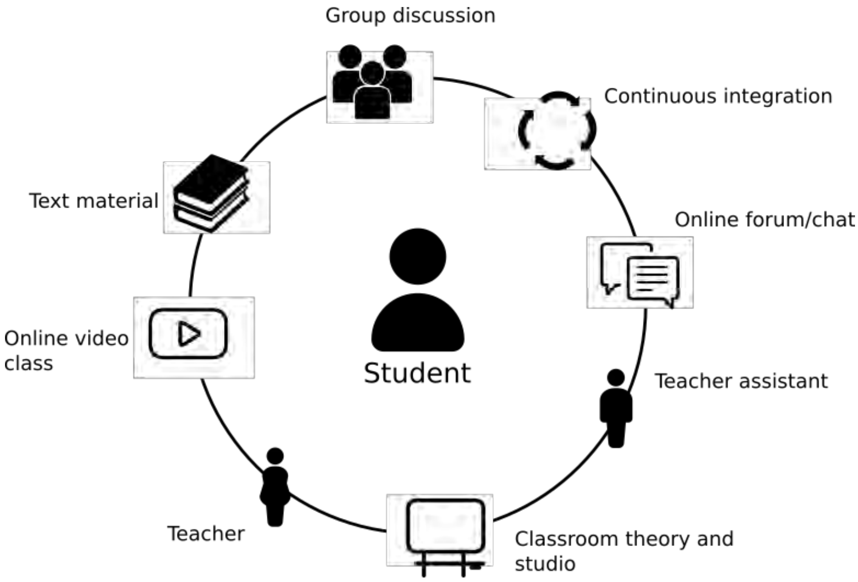


Figure 1. Flipped classroom and student support

The remainder of this paper is organized as follows. Section 2 will present some related works about the main topics of building a computer, continuous integration and agile. Section 3 will present the project students should implement. Section 4 will discuss the dynamic of classes. Section 5 will show some results of the last implementation of the course where the strategies were applied, and Section 6 will conclude the main ideas presented in the document.

2 Related Work

The course Elements of Computing Systems, also known as From Nand to Tetris (Nisan & Schocken, 2017) is one of the first successful Massive Open Online Courses taken by self-learners over the web and on Coursera (Coursera, 2017). In this course students should develop an entire computer from basic logic gates until operating system routines. The course has a complete software suit solution were students could test their developments in their own computer. This course was used as a reference for applying the strategies described in this document.

The Nand to Tetris course was oriented for individual self-learners, but in our case, we would like to bring a teamwork experience for students, which lead to several challenges, and at the same time opportunities, allowing students to develop their team skills. This also lead to questions on how students could plan together and collaborate in a same project, anytime and anywhere.

Continuous integration (Duvall, et al., 2007) is a project development practice, used in software development, that encourages developers to communicate and collaborate by merging their code improvements into a shared version control repository after every progress. Every change in the project is immediately tested and reported to the entire team. This strategy lets developers to be constantly updated about the project and any mistake or software misbehaviour is quickly detected, leading to better codes and higher software developer's confidence.

Solutions for automatic assessment are used in other educational areas, actually Massive Open Online Courses regularly use automatic assessment algorithms, usually together with peer evaluation. But Continuous Integration strategies have an advantage that it is a de facto standard widely used in the industry. Them it is possible to profit the strategy of automated tests, among other resources, and at the same time, students could get experience in a real industry strategy for software development.

Agile values and principles (Beck et al., 2001) are also a fundamental piece for the strategy developed. Agile is commonly used in software development organizations, which consists in working in short planned sprints, having at the end some working code. This strategy quickly adapts to changes, and reinforce the importance of communication. Agile team members usually have a short daily meeting where they discuss what they are going to do that day. Teams using agile usually plan their development efficiency, calculating an internal team velocity. These strategies were used in the class projects except the velocity measurement, what could be some future work.

3 Course Project

Projects in the computer engineering industry have a short time to marked period, with delivery time of weeks sometime, even in embedded system (Carbone, 2012). This is in compass with the current software publishing strategy of Continuous Delivery, where small developments of agile projects are made available as soon as possible (Chen, 2015). As educators, we should let our students' familiar and prepared for this project development processes, since this is used today and should be the common strategy for computer engineering projects in the future.

The continuous integration strategies, among other described in this document, were incorporated in a course for sophomore computer engineering students, which they were then challenged to build an entire computer from transistors, until operating system routines. The entire system was split into 7 phases were students were expected to implement one layer of the entire project each two week approximately. Students are organized in randomly created groups, and each group will develop its own computer in the entire cycle. Students remain in the same group for the entire term and each project phase becomes a Scrum sprint.

Figure 2 illustrate the used framework for continuous integration were students submits new implementation of the project and it is automatic checked on an online server integrated on the code repositories.

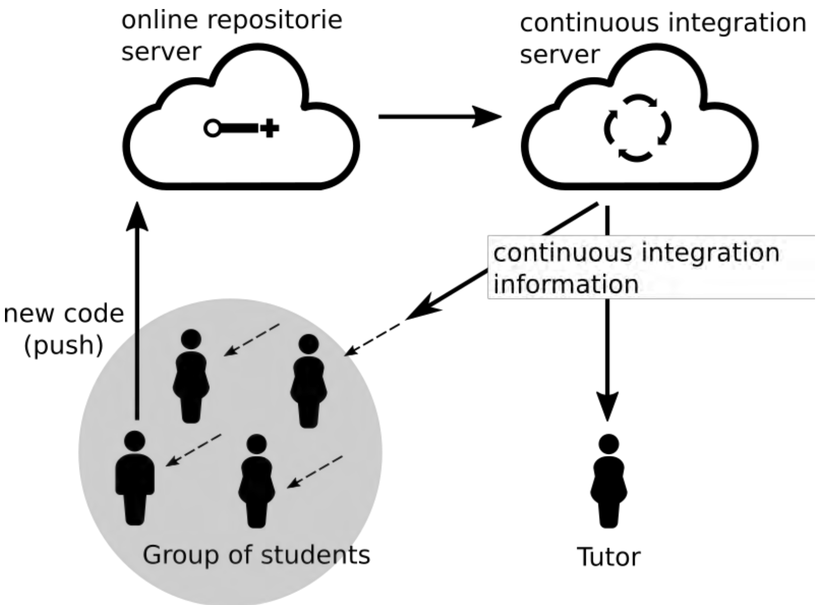


Figure 2. Framework of continuous integration used on the course.

Students fork an online repository (hosted on GitHub) that is supplied by the professor and then use that base files and directories structure to start their sprint development. This repository has some basic organization for the code implementation, and most important, all the test procedures are also available allowing students to check their progress. As presented in Figure 3. students will have a base project structure for their implementation. They will also have test routines for their development. Since they forked an original project, professor can see their evolution: as a group, and how each individual student is participating in the implementation.

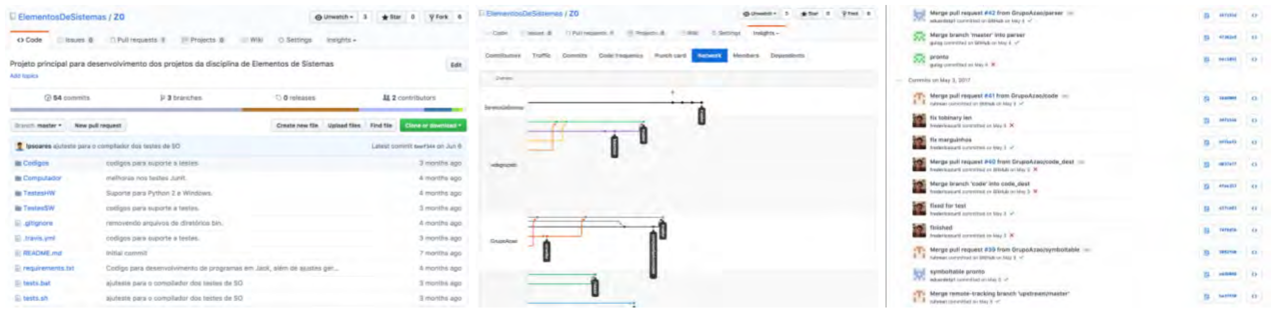


Figure 3. Screenshots of GitHub project with file structure (left), group project evolution (middle) and individual report (rinight).

4 Class Dynamics

Project Based Learning is an educational strategy being applied for some time and usually increases student motivation level and leads to a higher level of competence development. In order to prepare students for this, a typical class is organized in some sections. The first part is before the class itself, when students get prepared at home for the class, the second part is at classroom where students gets their hands on some isolated problem, a third part is the project itself, where they plan and work on it.

4.1 Content Delivery

Some minimum preliminary technical knowledge is required for starting each project phase, then in order to prepare students for the class and the project, a sequence of video lectures was made available for students, which they should see a specific video before attending the class. Quizzes are displayed for the student in the online browser in some strategic points during the video playback, just to confirm students are really understanding the topic. Figure 4 shows: some screen shots of randomly chosen videos pages, the management content tool used, and some reports about student's usage of the tool.

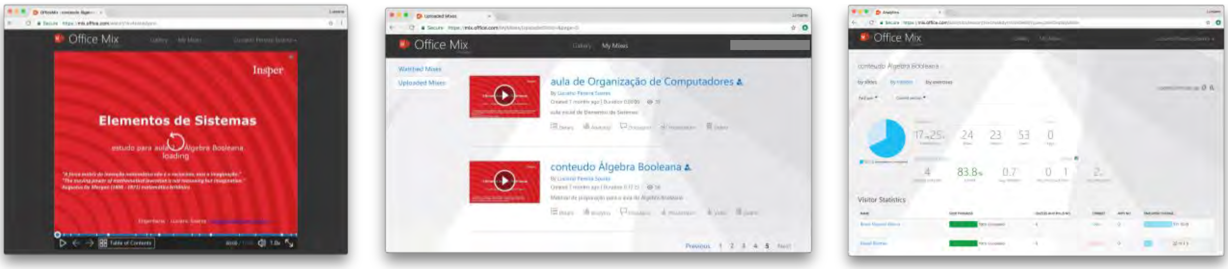
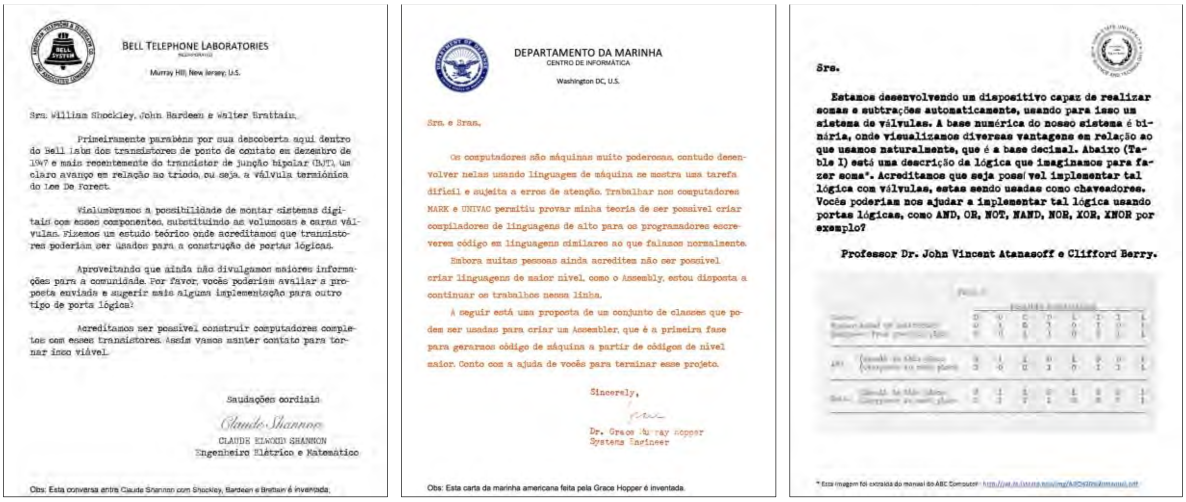


Figure 4. Video lecture (left), previous video and class slides (middle) and report with time and quiz answers (right).

4.2 Content Practice

At the beginning of some classes, activities are proposed for students, like challenges or exercises. This enable students to first experiment a knowledge topic in an isolated environment from the main project, avoiding interfering in a repository where several people are working at the same time. Although, these activities should be relevant for the project, since the main goal of the course is to enable students to build an entire computer. Class dynamics are then organized by handouts, that are handed over for students. In these documents, they could read some minimal explanation and see the planned activities for the class. In order to improve motivation and make students aware of the history of computer evolution, handouts were written as if some historical computer science personality is asking how to overcome some challenge. Figure 5 shows some handout's first pages used in the course.



BELL TELEPHONE LABORATORIES

Murray Hill, New Jersey, U.S.

Srs. William Shockley, John Bardeen e Walter Brattain,

Primeiramente parabéns por sua descoberta aqui dentro do Bell Labs dos transistores de ponto de contato em dezembro de 1947 e mais recentemente do transistor de junção bipolar (BJT), um claro avanço em relação ao triodo, ou seja, a válvula termiónica do Lee De Forest.

Vislumbramos a possibilidade de montar sistemas digitais com esses componentes, substituindo as volumosas e caras válvulas. Fizemos um estudo teórico onde acreditamos que transistores poderiam ser usados para a construção de portas lógicas.

Aproveitando que ainda não divulgamos maiores informações para a comunidade. Por favor, vocês poderiam avaliar a proposta enviada e sugerir mais alguma implementação para outro tipo de porta lógica?

Acreditamos ser possível construir computadores completos com esses transistores. Assim vamos manter contato para tornar isso viável.

Saudações cordiais

Claude Shannon

CLAUDE ELWOOD SHANNON
Engenheiro Elétrico e Matemático

Obs: Esta conversa entre Claude Shannon com Shockley, Bardeen e Brattain é inventada.

DEPARTAMENTO DA MARINHA
CENTRO DE INFORMÁTICA

Washington DC, U.S.

Srs. e Sras.,

Os computadores são máquinas muito poderosas, contudo desenvolver nelas usando linguagem de máquina se mostra uma tarefa difícil e sujeita a erros de atenção. Trabalhar nos computadores MARK e UNIVAC permitiu provar minha teoria de ser possível criar compiladores de linguagens de alto para os programadores escreverem código em linguagens similares ao que falamos normalmente.

Embora muitas pessoas ainda acreditem não ser possível criar linguagens de maior nível, como o Assembly, estou disposta a continuar os trabalhos nessa linha.

A seguir está uma proposta de um conjunto de classes que podem ser usadas para criar um Assembler, que é a primeira fase para gerarmos código de máquina a partir de códigos de nível maior. Conto com a ajuda de vocês para terminar esse projeto.

Sincerely,

Dr. Grace Murray Hopper
Systems Engineer

Obs: Esta carta da marinha americana feita pela Grace Hopper é inventada.

Srs.

Estamos desenvolvendo um dispositivo capaz de realizar somas e subtrações automaticamente, usando para isso um sistema de válvulas. A base numérica do nosso sistema é binária, onde visualizamos diversas vantagens em relação ao que usamos naturalmente, que é a base decimal. Abaixo (Table I) está uma descrição da lógica que imaginamos para fazer soma*. Acreditamos que seja possível implementar tal lógica com válvulas, estas sendo usadas como chaveadores. Vocês poderiam nos ajudar a implementar tal lógica usando portas lógicas, como AND, OR, NOT, NAND, NOR, XOR, XNOR por exemplo?

Professor Dr. John Vincent Atanasoff e Clifford Berry.

* Esta imagem foi extraída do manual do ABC Computer

Figure 5. Some handouts courses showing computer science personalities asking for help.

Most of the class dynamics are planned for students to work in pairs. Although they can work individually, working in two people showed an effective approach since students can quickly discuss ideas and find faster and better answers. The discussion in pairs is convenient, because students are talking, and consequently teaching each other, with the same language and context background what makes some part of the learning more efficient (Mazur, 2017).

4.3 Project Planning and Implementation

Students should organize themselves for the development, preferable in class time. Each sprint should have a different group facilitator assigned, and since groups are encouraged to use Scrum, they call this team facilitator as a Scrum Master. Students discuss what will be their strategy for implementing the computer layer defined for the sprint. They discuss the problem together and at the end they define tasks which someone (or more than one) should implement. Students use a shared Kanban board to organize themselves (http://trello.com/). The sprint facilitator is responsible to post all the tasks in the virtual board at the end of the planning meeting. After that, each student, or pair of students, select a task they want to implement and define, in the online system, that they are responsible for.

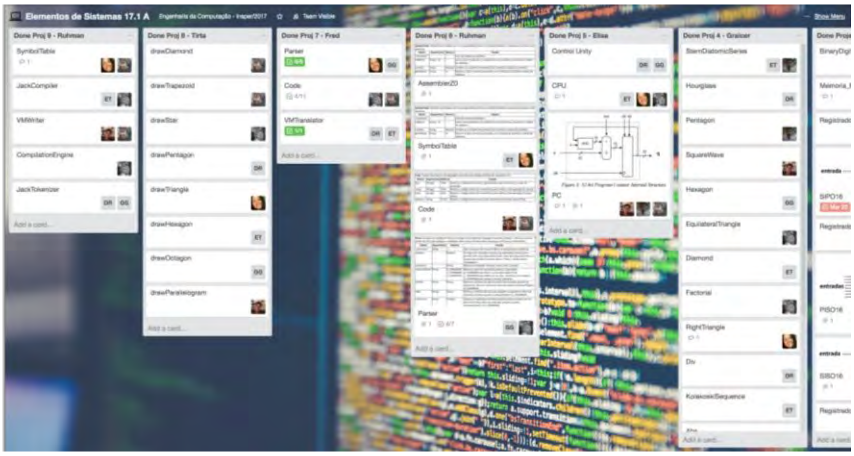


Figure 6. Students Kanban board.

As students start to implement the project, they can run the continuous integration tests procedures locally, but what is more convenient is that the test procedure can run in a remote server, in the cloud. These servers are testing and evaluating their development, after any code submission. That way the entire team can see what is going on, and help as necessary other. Students submit their contribution in a git development branch repository, which will not affect the main project if there is something wrong in the implementation, but the person who implemented the code and the rest of the team can see what was done. In the case everything is correct, some team member, different from the developer, checks if everything is correct, and them approve the submission and merge this code with the main code, otherwise the student that was checking the development can propose some idea for solving the problem, and the student that originally developed the piece of code can fix it.

Test procedures runs in the cloud server every time a new code is submitted to the remote repository. A separated test block was created for each sprint, then it is possible to check if the new code is ok in that part, but in fact past implementation affect future sprints, then it is important to track all the project evolution. Figure 7. shows the feedback page students receive when they are implementing the project. It is possible to see what is going on, how long it takes and if the development passed or not the test. It is also possible to see a detailed description of the test routine, then students can dig into the test messages and discover what is wrong with their code. The test routines have also to adapt for the code development required, for instance some project phases are oriented to image generation development, then a computational vision test routine, made on OpenCV (https://www.opencv.org/) was made available to students.

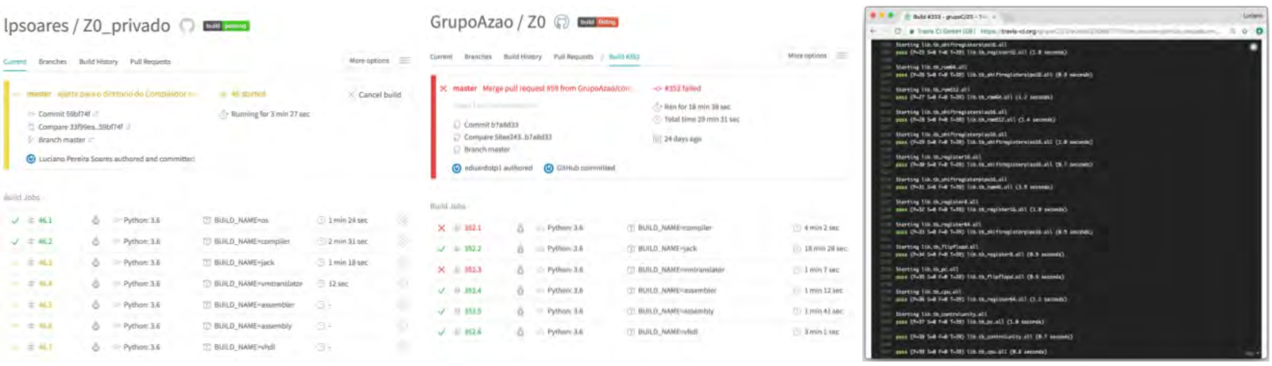


Figure 7. Project being tested (left), project with problems (middle) and detailed report of what was tested (right).

Students are encouraged to check in a quick daily meeting what is going on that day, and if someone has troubles, the rest of the group can help. Students have also to show at the end their sprint, in a Review Meeting, a final project deliverable. In this Review Meeting, professor and other students can see how the project evolved in a particular group. Finally, there is a retrospective meeting, where students point what worked well, what was an impediment, and what they could change in their internal process.

5 Results

Students were watching the video lectures before class. In the first weeks, basically the entire class watched all the videos, by the end of the term, this dropped for half of the students. According to students was more difficult to follow the video lectures since they get larger and other courses were more demanding. It is true that videos get longer since the first videos were target to 15 minutes, but the last ones were around 40 minutes, what could really have compromised the attendance.

At the end, after the 7 project phases, students were able to finish most of the computer implementation. Some parts, specially at the final phases, were not completely implemented, but some code was supplied to allow them to check the result. They passed by each planned phase, and they can have their project running in a real device (Figure 8). The project was designed to run in a FPGA DE0-Nano. This is a programmable hardware where they can program the hardware in VHDL (VHSIC Hardware Description Language), which is the language used for the first half of the project. The second part, mostly software layers, were developed in Java, and this decision was taken due their experience and relevance for other learning goals in the course, like object-oriented programming. Contributions to code can be tracked as presented in the graphics in the left of Figure 8, each graph is showing the total commits students submitted in each group.

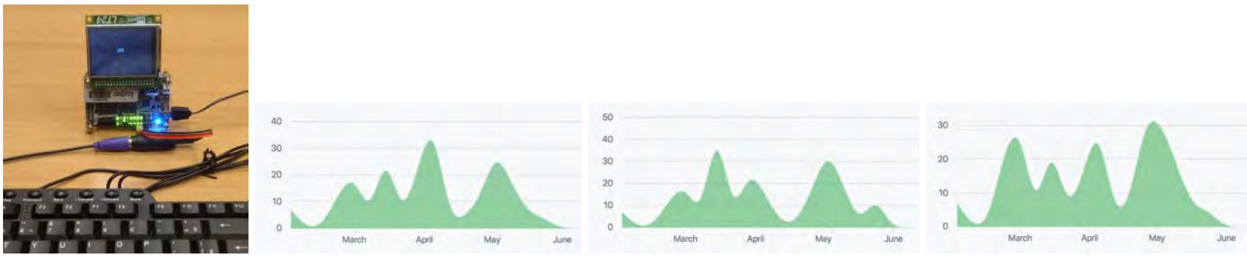


Figure 8. Project developed by students running in a FPGA and their contribution to the code in their groups (number of commits).

In a first moment, the pedagogical strategy developed limits the project autonomy, since the automatic integration and test procedures demand some prior project organization, but as the project evolve and students get more comfortable with the infrastructure, they start to develop their own tests and they shape the projects the way they decide.

Due the high dependency among tasks, student communication needs are higher than a regular course or project. The recommended tool informed for students to communicate and share possible contributions was the Slack (http://slack.com/), but some group of students decided to use WhatsApp for their team communication.

6 Conclusions

The main course goal was to make students capable of building an entire computer from transistors, until higher operating system levels. Most of students get prepared for the class watching the videos, specially at the begging of the course. During class time, students were motivated with the planned activities. They were not graded in these activities, but it is clear that they try to do the activity with care, in their speed. Projects were also developing some important skills, like team work and communication, these skills were evaluated by specific rubrics, and students were comfortable with that. Finally, a formal test was conducted at the end of the course to confirm the theoretical part was understood by them.

In the first edition of the course, students could get the theoretical content knowledge from a previous reading, but faculty perceived a too low reading rate, which compromised the class dynamics. That's why, in a second edition, video lectures were recorded to students, with some quizzes during the video. This solution also allowed faculty to monitor how students were getting prepared for the class, and if they are understanding the content. Some peculiar behaviour from students was the fact that since the video tool allowed them to watch the video in different speeds, students usually preferred to see the video two times faster.

Usually, project sprints were delivered on time by the students, but submission track shows that students work in the project mostly in the classroom time, as expected, and in the few hours before the deadline. Although we discuss planning strategies in class activities, they only organize time to finish their work in this last-minute effort. Plagiarism was not a problem detected, although students could find their colleagues project on internet, faculty could not identify any plagiarism in the projects in this last term. Analyzing the student repository on average each student contributed with 20 commits and 1000 line-of-code insertions and 150 removals.

As a future work, an evaluation of the use of EduScrum (http://eduscrum.nl/en/) as an alternative or additional tool for the proposal will be conducted. Some phases, mostly the final phases, were too much complex for students, then an approach for dividing the requirements in more phases is also being evaluated as a future work.

Finally, the student's feedback about the course, shows that complaints aims to tools and not the pedagogy. Students report that developing in VHDL is too complex and the literature available is inconsistent. Since this is a weaker point in the course dynamics, there are future plans on changing the description language or internally creating a focussed documentation for that. But on the other hand, the pedagogy is motivating students to learn more.

7 Acknowledgments

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The Result of Research as a Meaning of Learning Instrument in Logistics Courses of the Technology Colleges of the State of São Paulo

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Abstract

A Technological Education College Center has 68 campuses in the State of São Paulo, of which nineteen have Logistics courses, with over of five thousand students enrolled. An itinerant Logistics Congress is held annually where students are invited to write articles and / or submit their course completion papers in the form of a scientific paper. At the last edition of the Congress that took place in May 2017, 622 papers were submitted, of which 461 papers were approved for oral presentation, and 49 papers were presented as a poster presentation. Assuming the arguments that to develop the competences of students with critical autonomy, creativity and intellectual curiosity, teaching by research is efficient as a competent instrument of professional and personal development, we used theories of meaningful learning which state that the acquisition of knowledge is only possible with the use of a pre-existing general concept (Ausubel, 1980), and the Research Learning Theory (Demo, 1990) that advocates learning through research, where students construct knowledge and develop competencies to apply theories in solving problems. This article aims to highlight education through research identifying which are the main topics researched by students of the Higher Course of Technology in Logistics from this Technological Education College Center submitted to the annual congress promoted by the Institution. This exploratory study was carried out by means of an analysis of the titles of the works presented by a qualitative analysis software, in which the main research themes of the students by economy sector and by campuses were listed and compared with the formative course evidenced in the Curriculum.

Keywords: Learning by research, Meaningful learning, Congress of Logistics

1 Introduction

Due to the characteristics of the students of the XXI century, it is necessary an educational system that stimulates the interest and the creativity, so that they can produce and make difference in their lives and in the community, for it must be created an area of intellectually vibrant and emotionally healthy, with a research center, so that there is not only a place of reproduction of what already exists, but the production and construction of knowledge. (Blickstein, 2010)
With this scenario, the active methodologies can contribute as the students experience the learning situations, guided by their masters and who enjoy the search for knowledge, and from this they will always be ready to face problems and to lead innovative projects. (Blickstein, 2010)

For Demo (2015), the educational system must be entirely based on research, where the process of knowledge construction is developed by the teacher through reconstructive questioning. It is not possible to get out of the maneuvering condition, without forming a critical conscience and to challenge on its own initiative, making this questioning the path of change.

For the technology colleges based in the state of São Paulo, composed of 68 campuses where nineteen have the technology course in logistics, a congress was created by the coordinators for the students to publish their researches, and to encourage them to make research using Problem Based Learning Methodology (PBL) where students construct knowledge by solving problems using the research and guided by teachers. This article aims to present an analysis of the main research subjects submitted to this event, field of activity and location of the campus, with the aid of qualitative analysis software, the result of which can be used as an important instrument for improving the course and as tool of public policy of education.

2 Scope

2.1 Learning and PBL

Ausubel et al. (1980) argue that the main problem of learning is the acquisition of an organized body of knowledge and the stabilization of interrelated ideas that constitute the structure of the subject. Therefore, in teaching situations, resources should be used to facilitate the transition from the conceptual structure of the subject to the student's cognitive structure, in order to make the material meaningful. They also discuss the use of dissertation tests to measure organization, cohesion, and integration of student knowledge (in addition to multiple-choice tests), and the use of simulated, real-life and work sample performance tests (particularly in applied subjects), however problem solving can be considered one of the most effective ways to assess whether there has been transfer in a meaningful learning process.

Developing problem-solving tasks and evaluating them, on the other hand, is not a simple task. Therefore, this subject will be further elaborated below, based on the studies of several specialists in this area and considering that the transfer of problem solving in Psychology can be seen as a cognitive function or as a teaching procedure.

The ability to solve problems requires qualities (flexibility, resource use, improvisation skills, originality, sensitivity to problems and spirit of adventure) that are less generously distributed in the apprentices population than the ability to comprehend verbally presented materials, or other form.

A valid distinction between "doing" and "understanding" is then proposed. Understanding is a necessary condition, but not sufficient for meaningful problem solving (the kind that involves a genuine understanding of the underlying principles - not trial and error procedures or simple pragmatic rules of practice). The doing, if it is of a routine or mechanical nature, does not presuppose or necessarily increase understanding.

For Sternberg (2000), in the cycle of problem solving, seven steps can be considered: a) problem identification; b) definition and presentation of the problem; c) formulation of the strategy; d) organization of information; e) allocation of resources; f) monitoring and g) evaluation. According to this author, cognitive psychologists, in general, classify problems as having clear paths to a solution or not. Problems with clear paths are often termed well-structured (or well-defined) problems. Those who do not have clear paths are called badly structured (or ill-defined). Problem-based learning is integrated and complemented with practice-based learning (Barrows, 1994) and aims to fully achieve reality-based learning. The use of problem solving, linked to instructional materials, must consider that often the same situation can be considered as a problem for one person and not for another, that is, the problems considered by the masters are not always the problems of the students , and vice versa (Pozo, 2002). During problem solving one needs to: make the apprentice familiar with his own decisions about the solution process, promote co-operation between learners in the performance of tasks, and provide students with the information they need during the solution process support work.

2.2 Learning through research

Learning is a process of rebuilding knowledge, at the service of education processes, where the challenge is to learn. In this context, learning is a process from the inside out, the teacher is the mentor, and has a role of guiding, supporting, encouraging and evaluating, but not protagonist, this role falls to the student who is assigned to think, create, read, argue, working with reality from your point of view. (DEMO, 2009)

Learning requires specific conditions, which is why Demo (2009) highlights six strategic dimensions: a) research, a way to learn to learn; b) own elaboration, critical and creative autonomy; c) involvement, commitment; d) evaluation, permanent diagnosis; e) orientation, role of the teacher; f) pedagogical relationship, in order to foster autonomy.

The teacher needs to propose his / her way of theorizing and practicing research, keeping it as the main source of his / her inventiveness. Education through research supposes some care in the teacher and in the student, for the quality of the education that implies in the formation of the formal and political competence. The questioning ability to reconstruct knowledge is based on methodological procedures that generate knowledge, and makes them innovative in both theoretical and practical terms.

It is also up to the teacher to reconstruct the pedagogical project and not to voice theories of others. This process of reconstruction of the project obeys the normal procedures of all reconstructive questioning work, without there having to be a previous format or a closed recipe. This process will demonstrate more abreast, who learns, presents innovations and problem-solving skills in life (DEMO, 2015), which allows the development of an autonomous student (FREIRE, 1996).

For Demo (2009), one should expect from public universities that they gradually adopt the application of learning by research, it is absurd to keep institutions as mere places of teaching. The public power has the duty to make these institutions in excellence, which shows the most advanced competence possible. As a result, they should be marked by research and own elaboration, in the name of competent and competitive citizenship.

3 Case Study

The Center of Technological Education is a public institution based in the State of São Paulo, based in approximately 300 cities, the institution manages 221 Technical Schools and 68 Technology Colleges, surpassing 290,000 students in technical courses and high school level and higher level.

The Technical Schools serve more than 211 thousand students in the Technical, High School and Integrated Technical Education to High School, with 140 technical courses for the industrial, agricultural and service sectors, including classroom, online, mixed, online, Youth and Adult Education - EJA) and technical specialization.

The Faculties of Technology exceed the mark of 80 thousand students enrolled in 73 technological undergraduate courses, in several areas, such as Civil Construction, Mechanics, Information Technology, Logistics, Tourism, among others. Besides graduation, postgraduate courses, technological updating and extension are offered.
The Technology Education Center has 68 campuses in the State of São Paulo, of which, nineteen have the higher level of logistics course with over thousand students enrolled.

The College of Technology in Logistics is inserted in the technology axis of Management and Business.

According to the Pedagogical Project, the student of the Higher Course of Technology in Logistics learns to determine costs, such as freight and taxes, to plan transportation routes and delivery of goods with effciency, quality, on time and at competitive prices. Therefore, the disciplines of Operational Research, Production Management and Operations, Calculus, Statistics, Financial Mathematics, Business Economics and Finance are important. The student also studies means of transport, their characteristics and advantages. He also learns to manage a stock, to create product packaging that facilitates storage and transportation, and to use cargo simulation software and roadmaps. Management, foreign trade, international logistics, English and Spanish complete the curriculum.

At the end of the course the student will be able to develop activities such as: Manage the flow of products or people in a company, take care of the acquisition, receipt, storage, distribution and transportation of products, as well as the control and processing of orders.

You can also determine, for example, the quantity and type of vehicles needed for delivery, and plan the organization and ordering of the products inside trucks or containers.

Operationally, it will be able to set up the route of delivery of the products, define the best place to make a stock, and also act in ordering the flow of customer service in hospitals and service stations.

To work in industries and factories, you will have developed skills to determine the layout of equipment and production sectors to improve productivity and avoid waste and rework.

As additional skills you will know how to work as a team and have some familiarity with computer science, because in the day to day work will use specific programs in the area.

In general, he starts his career in storage, warehousing and product inventory functions. All companies, large and small, need to have a logistics professional, since this area is crucial to cost savings.

There is an extensive field of work in the area, such as industries, supermarkets, shops, hospitals, public urban mobility agencies, specialized companies (logistics operators), transport companies and e-commerce companies. More and more logistics services have been outsourced, which opens space for those specialized in the sector.

Since 2010, a conference is held annually by the Technology Education Center, which is organized by the committee of coordinators of the Higher Course of Technology in Logistics, when students are invited to write articles and / or present their course completion papers in form of scientific article. The congress has as a target audience Professionals, academics, researchers, entrepreneurs, students of Logistics, Production Engineering, Administration, Information Technology, Port Management, Business Management, Foreign Trade and other related courses.

In the edition of the congress that happened in May of 2017 were submitted articles segmented by the following areas of knowledge: Operations Management & Urban Logistics; Quality management; Economic Management and Business Finance; Product Management and Service; Operational Research; Knowledge Management, Business Strategy & Entrepreneurship; Technological Education; Environmental Management and Social Responsibility; International Logistics and Foreign Trade.

A total of 622 papers were submitted, 46 of which were approved for oral presentation and 49 papers were presented as a posters.

During the congress, activities are carried out such as lectures with professionals and industry experts; Minicourses; Presentation of research projects developed by authors related to the Center of Education and higher education institutions of Brazil; Thematic rooms; Participation of technological solutions providers, logistics service providers, training companies, among others.

4 Results

The participants of the Congress submitted the works with a wide variety of topics related to Logistics and its sub-themes, followed by the themes that surround the other topics related to Management, according to chart 1 and 2 below:

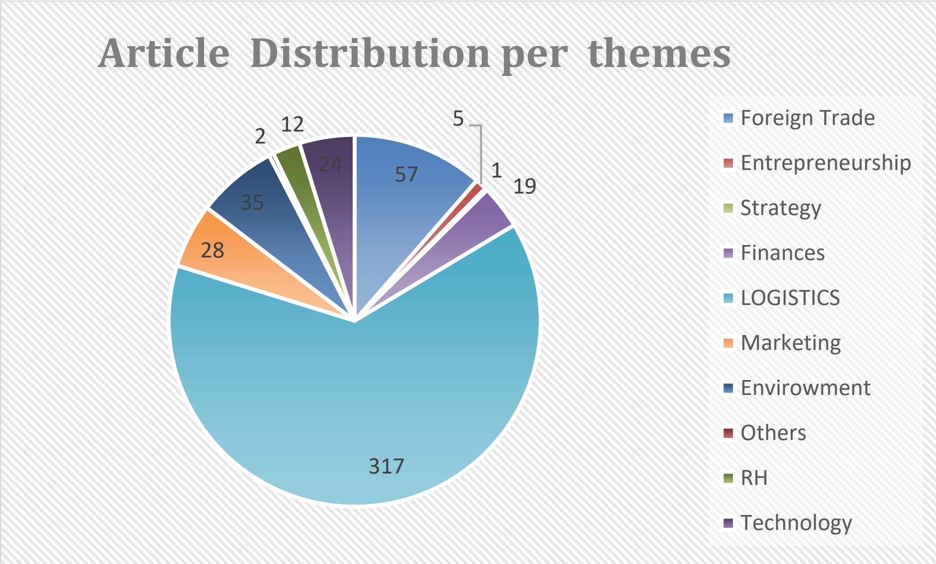


Figure 1: Article Distribution per Themes

Figure 1 clearly shows the focus and objective of the course being fulfilled with the vast majority of the papers presented with themes related to logistics, followed by the theme Foreign Trade, a theme complementary to the Logistics course, followed by Technology (Information Technology linked to Logistics) , Environment, Finance, Marketing, Entrepreneurship, Human Resources (HR) and Strategy. On the other hand, the detailing of the themes submitted to the logistics sub-themes analyzed in Figure 2 shows the students' preference for research themes.

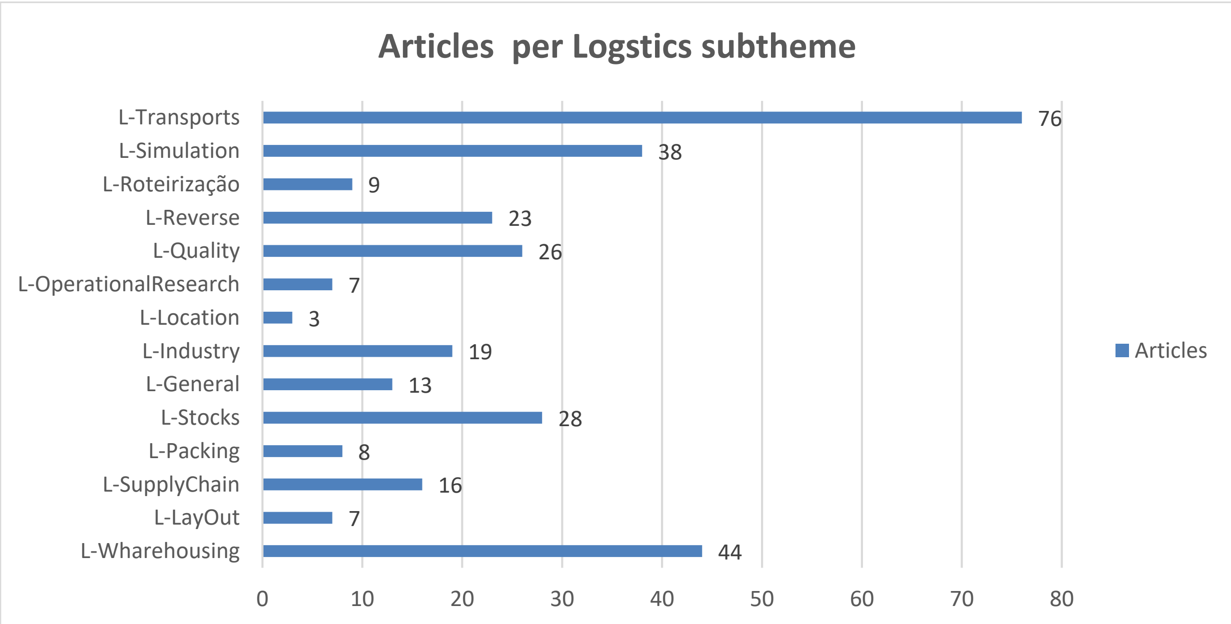


Figure 2: Articles per Logistics subtheme

Figure 2 shows a great inclination of the students for the research on Transport. Included in this item were all Modes of Transportation, Intermodality, Multimodality and Urban Mobility; This topic was followed in descending order by Storage, Simulation, Stocks, Quality, Reverse Logistics, Industrial Production (Industry), Supply Chain, General Logistics, Packaging, Routing, Lay Out and Operational Research and Location. This result shows the main topics of research interest of the students of the technological courses of logistics, all clearly linked to the disciplines arranged in the curricular matrix of the Course.

The analysis of Figure 3 shows the research themes by region of the original campus. The 68 units were divided in Greater São Paulo, the interior of São Paulo, the coast of São Paulo and Vale do Paraíba, showing a strong correlation between the research themes, the curricular matrix with its 25% of elective courses dedicated to regionalization of the course and the economic vocation of the region.

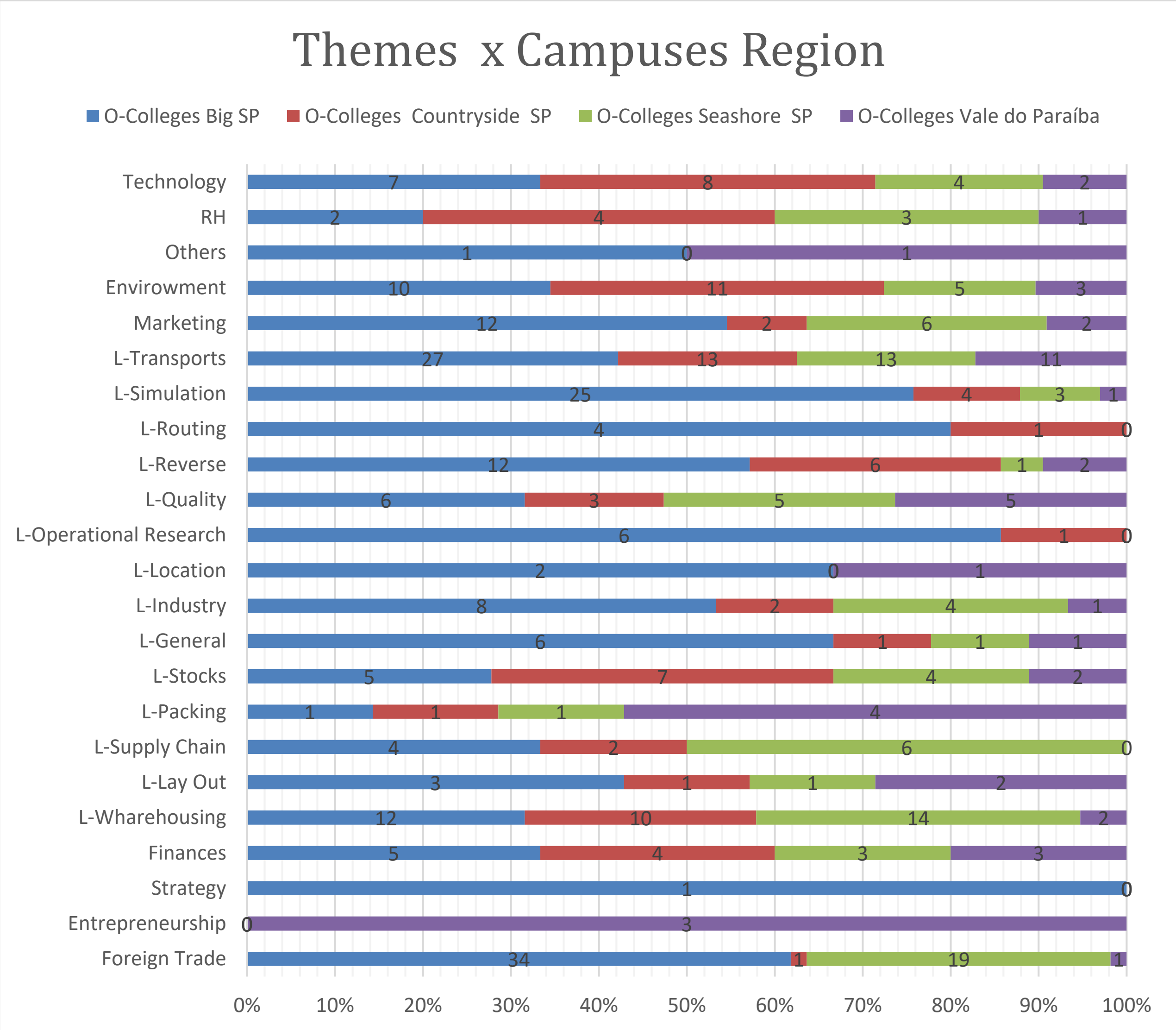
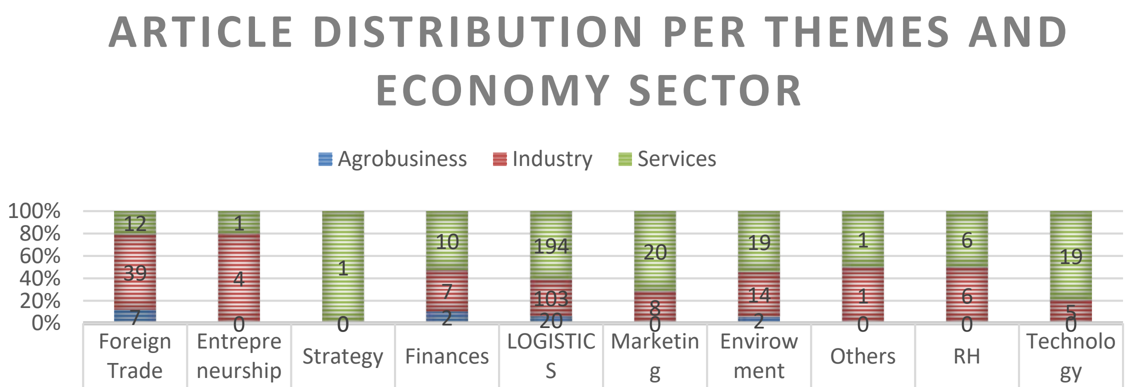


Figure 3: Themes x Campuses Region

The analysis of Figure 4 shows the research themes by sector of the economy (industry, agribusiness and services, and services encompass services and trade), this graphic shows us that the themes of Foreign Trade and Entrepreneurship were Industry, a strong presence of the services sector.



	Foreign Trade	Entrepreneurship	Strategy	Finances	LOGISTICS	Marketing	Envirowment	Others	RH	Technology
Services	12	1	1	10	194	20	19	1	6	19
Industry	39	4	0	7	103	8	14	1	6	5
Agrobusiness	7	0	0	2	20	0	2	0	0	0

Figure 4: Articles Distribution per Themes and Economy Sector

5 Conclusion:

By means of an analysis of the titles of articles submitted to an Annual Logistics Congress using qualitative analysis software, the main themes studied by the students of the Higher Course of Technology in Logistics were investigated. The result showed a strong similarity between the chosen subjects and the main disciplines taught in the course where the center of students' motivations focused on the themes Logistics and its sub-themes, followed by the theme Foreign Trade.

All submitted articles pass through a double blind review process and the approved ones, were incorporated into the Congress Proceedings to make accumulated knowledge democratic and accessible and available to the relevant academic and business community source of information and knowledge.

The research found limitations regarding its process of analysis due to the precarious register collected by the OCS system, Open Conference System, standard of organization of academic events. For the next edition and for continuity of this work of research will be made improvements in the registry of authors in the system for future analyzes to be more profound.

It is concluded that the objective of this article was achieved by raising the topics of research interest of the students by theme, by sector of the economy and by location of the campus of origin of the article.

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Reduction of Maintenance and Operation Costs in Ores Transportation: a case study

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Abstract

This work presents a case study on reduction of maintenance and operation costs of a metallurgy and mining branch company that operates in the transportation of ores from the mine to its industrial facilities. The company has thirteen dump trucks in its vehicles fleet used to the service. Along the years, the company has been facing problems with its trucks. The trucks structures have been suffering cracks due to material fatigues, causing unscheduled stops and damaging the following steps of the company's production. In order to solve these problems, it was proposed the change of material structures of the trucks, from carbon steel to high strength niobium micro-alloyed steel, as well as in their bucket in two samples of trucks to observe the new performance of them. By using this new material, it was possible to develop a new model for the structures and components of the trucks. With this redesign of the structure, there was a reduction of 25 % of the allowed mass of the bucket, which provided an average increasing of transported load from 40.0 tonnes to 41.1 tonnes per trip, resulting in a saving of 3 % in the total cost of transportation and a fuel consumption reduction of 6 %. Until this moment no fatigue cracks have occurred. This new model of trucks is being used in the last four months of service using high strength niobium micro-alloyed steel material.

Keywords: Micro-alloyed steels; Transportation cost; Fuel consumption;

1 Introduction

As in all industries in the corporate world, mining companies must be worried about themes like cost reduction and must improve their products and services to. According to COSTA, SOUZA and PINTO (2005), the main objective of the production planning in an open pit is to determine the speed of mining that will be implemented in each front of use.

In this work, we have analysed a case of a company in the field of metallurgy and mining that was facing availability problems in its fleet of trucks that are used to transport ore, which leaves the open pit and go up to the industrial facilities to continue the production of the material.

The company has a fleet of 13 (thirteen) dump trucks equipped with a half-mast bucket of 20 m^3 (Figure 1) with internal protection coated using Ultra High Molecular Weight (UHMW) material (noble thermoplastic with advanced properties, high strength impact, low abrasion, low coefficient of friction, light and low probability of cracking) to avoid that some part of the ore remains trapped inside and furthermore unload the full material.

The company transports a total volume of approximately 12 million tons per year divided in 300 thousand trips, traveling an average distance of one kilometer from the mine to the industrial facilities that demand an average annual use of 390 thousand liters of fuel.

Figure 1. Truck 4844 MBB – Actros - Source: 69° ABM's annual congress - www.abmproceedings.com.br

By looking to the ore transportation operation, unplanned stops of these trucks were identified. These stops occurred due to cracks and fissures in the old trucks' dumper (Figure 2). These buckets used to be produced by using low mechanical strength steel (Carbon Steel) as well as their sub-chassis. These stops used to result in lower availability and higher number of stops than stipulated for the process.

According to Arbache (2011), to be successful in some market, it is necessary to guarantee the availability or high level of logistics service. This means managing inventory management with excellence in distributive processes.

Figure 2. Crack in sub-chassis and in the bucket - Source: 69° ABM's annual congress - www.abmproceedings.com.br

The replacement of the bucket and sub-chassis manufactured with steels of low mechanical resistance by high resistance steels microalloyed to the Niobium was done in 2 trucks to analyse its performance, which brought a difference between the structures according to the Table 1.

Table 1. Materials Comparation – Old truck versus New truck.

	Previous Project	Plate Thickness (mm)	New Project	Plate Thickness (mm)
Dump Truck	Actros 4844 Model 2011	- -	Actros 4844 Model 2013	- -
Bucket	Floor: S355 Side Carbon Steel Structure: Carbon Steel	9.5 6.3 -	Floor: Hardox 450 Side: Hardox 450 Structure: Domex 700MC	6.35 4.0 -
Sub-Chassis	Structure: Carbon Steel - -	Longitudinal Profile: 8.0 Reinforcements: 6.3 Transversal Structure: 4.75 – 9.5	Structue: Domex 700 MC - -	Longitudinal Profile: 8.0 Reinforcements: 6.3 Transversal Structure: 4.75 – 9.5
Weight (Kg)	Dump Truck Bucket Total	11,074 7,426 18,500	Dump Truck Bucket Total	11,530 5,470 17,000

Source: Prepared by the authors adapted from the 69° ABM's annual congress - www.abmproceedings.com.br

Table 2 shows the flow limit (FL) and the resistance limit (RL) of the materials and the comparation of the differences between the old and the new project, expressing the performance in the ore transportation due to the application of Niobium microalloyed high strength steels in the truck bucket structure.

Table 2. Materials – Resistance limit and material flow.

Materials	FL (Mpa)	RL (Mpa)
Carbon Steel	260 - 380	360 – 510
Hardox 450	1,270	1,450
Domex 700MC	765	810

Source: 69° ABM's annual congress - www.abmproceedings.com.br

In addition to these gains in terms of structure and load, it was found that with the use of the new buckets (more resistant and lighter), the fuel consumption while the truck is empty (returns to the mine) is smaller, as well as the emission of carbon dioxide (CO_2).

According to IPEA (2011) the amount of CO2 emitted per type of fuel is given in the Table 3:

Table 3. CO_2 emission per type of fuel

Fuel	CO_2 emission (Kg/L)
Gasoline	2.269
Anhydrous Ethanol	1.233
Hydrous Ethanol	1.178
Diesel	2.671
GNV (Kg/m^3)	1.999

Source: IPEA, 2011.

2 Objective

The present work has pointed as objectives: to analyze the impacts that the change of design of the buckets brought in the cost management, maintenance, operation and availability of the fleet of trucks in the productive process.

Analyzes were defined through the number of stops caused by fatigue cracks, impacts on productivity and availability of those trucks (percentage), return on investment, reduction of costs in internal logistics (proportional increase of transported load), reduction of maintenance costs (fewer unscheduled stops) and reduction of carbon dioxide emissions (CO_2) (lighter trucks while unloaded).

3 Methodology of measurement and tools application

In order to obtain the expected results, it was established relations between variables in the study of object analyzed.

The study used data reports from the previous project, and then a comparison was made with a sample of two (2) trucks which were submitted to the use of the new bucket.

After data analysis of the new project, evaluate the total exchange of the fleet of trucks. The data chosen for the analysis are presented below:

Number of unscheduled stops;

Unplanned stopping time;

Fuel consumption;

Kilometers traveled;

Average load transported per trip;

Total number of stops (scheduled and unscheduled).

These data were collected monthly for 12 months, to analyze the difference between the behavior of both projects, applying the availability calculation formulas, the difference between unplanned stopping time, fuel consumption efficiency, the amount of carbon dioxide emission of the old truck and the transported load efficiency.

In order to analyze the old and new trucks performances, the following considerations were used to compare the results obtained in the research:

3.1 Difference between unscheduled stop times (hours):

$$Old\ project - New\ project$$

3.2 Availability of new and old trucks (percentage):

$$\frac{Total\ available\ time - Total\ stopped\ time}{Total\ available\ time}\ x\ 100$$

3.3 Efficiency in fuel consumption:

$$\frac{Km\ traveled}{Fuel\ Consumption\ (L)}$$

3.4 Sustainability:

$$Fuel\ Consumption\ x\ 2{,}671^*$$

* 2,671 is the amount of CO_2 emitted per liter of diesel.

3.5 Fuel Consumption (liters):

$$Old\ project - New\ project$$

3.6 Transportation efficiency (Old and New Design):

$$Transportated\ load - \ Number\ of\ trips$$

In relation to the financial gains, the Return on Investment (ROI) formula was used to analyze the actual gains. The used formula is shown below:

$$ROI = \frac{(Total\ revenue - Total\ Cost)}{Total\ Cost}$$

4 Results

Table 4 shows the data related to the comparison of old truck and new truck. As can be seen the number of unscheduled maintenance and unscheduled stops have not occurred. So an increase in the availability were obtained.

Table 4. Results – Old truck versus New truck.

Data	Old Truck	New Truck
Unscheduled stops (Number)	16	0
Unscheduled stops (Hour)	64	0
Efficiency in fuel consumption (Km/liter)	1.53	1.59
Sustainability (amount of CO_2 in Ton/year)	80,130	75,028
Fuel consumption	30,000	28,090
Number of Travel Needed (12 million Ton/year)	23,076	22,459
Km driven	46,154	44,919
Diesel price (Liter)	R$ 3.33	R$ 3.33
Fuel costs	R$ 99,900.00	R$ 93,539.70

Source: Prepared by the authors.

The availability of the trucks increased because there were no longer unscheduled stops for maintenance that occurred each 500 hours of work. Regarding to this point, it was observed that no more non-scheduled maintenance have occurred.

5 Conclusion

Due to the reduction of the weight of each truck about 1,500kg it was possible to increase 1,5 tons of material loading each trip. A reduction of 10,843 trips per year is projected to the complete fleet. Basing on the monitoring period there was an average increasing of 1,1 tons per trip what can reach a reduction of 8,030 trips per year.

This reduction in weight led to a 3 % reduction in transportation costs compared to the 4 % projected at the beginning. These costs refer to fuel consumption, other items such as tire and oil, caused a reduction in order of 6 % in the fuel cost as shown in Table 4. The reduction in fuel consumption is due to the reduction of the weight of the truck when traveling without load (return to ore mine).

With the design of new buckets, a monthly reduction in order of 1,910 liters of diesel consumed was obtained according to Table 4. Using the data of Table 3, which shows that 1 liter of diesel is equivalent to the emission of 2.671 kg of carbon dioxide (CO_2) in the atmosphere, the reduction of CO_2 emissions was around 5,1 tons.

Considering the economy obtained and the financial investment of 12 % more in the new project in relation to the previous one, the payback of this, was obtained in the first year of work. There were no cracks or fissures caused from fatigues in the new components until the present moment.

Therefore, the costs, maintenance time and unavailability have decreased. As the non-scheduled maintenance, due to cracking must be corrected by welding, which require more time for maintenance. In conclusion, if these types of failure no longer occur, it could show that maintenance management can be operated with complete control and predictability.

In conclusion, the management of the maintenance of the company brought a considerable payback once decreases the costs and the loss due the stops of the trucks.

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Active Learning On-Line – a challenge explored

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Abstract

The benefits of active learning (AL) - and more specifically problem-based learning (PBL) - as an effective approach to teaching and learning are supported not only by current learning theories but also by empirical evidence. Similarly, the benefits of the use of information and communication technology tools in teaching and learning, for example in connection with what has been termed 'the flipped classroom', are well documented. A challenge, however, is how to secure students' active learning in connection with online learning. In this paper we will address the question of how to implement PBL learning principles in online learning material to be used in a flipped classroom situation. We will do this through a presentation of our work with designing case based open source learning material, based on some of the main principles of problem based learning, such as, authentic real life problems, collaborative learning and contextualisation, followed by a self-critical analysis of the strengths and - more importantly - the weaknesses of the prototype material developed.

The present case scenario is based on a development project providing water and electricity supply systems to a training workshop for disabled women in a small village in Kenya. We will present the design process, the experiences gained, the lessons learned and the recommendations extracted from our first attempt to develop online learning material.

Keywords: Active Learning; problem based learning; online learning material; flipped classroom.

1 Introduction

Problem Based Learning (PBL) is an active learning approach that has gained popularity in engineering education throughout the world, due to evidence of impressive results in terms of student motivation and learning and in terms of employer satisfaction with the graduate engineers (Bjerregaard & Mølsted, 2004). Similarly, the use of information and communication technologies (ICT) in teaching and learning in higher education has spread throughout the world. ICT is used for a multiplicity of educational tasks, from simple upload of learning material on a digital platform via more sophisticated flipped classrooms to highly interactive virtual collaboration between students in different locations and in different countries.

The most fundamental principle of PBL is that an authentic real-life problem is the starting point for the students' learning processes. In a face-to-face study environment, this principle may be implemented by bringing students out of the university into the local society, to talk with stakeholders and to identify, analyse, formulate and possibly solve local real life problems. If, however, we want students to gain experience with working in another cultural setting than their own, in order to give them opportunities to develop useful intercultural skills for a globalised world, costs of bringing them 'out of the university' may be prohibitive. Instead, we can draw on the flexibility of ICT to give students access to real-life problems embedded in another cultural context via cases on a digital learning platform. Such cases should be based on authentic stories of engineering practice in the given culture to comply with the above mentioned PBL principle.

In this paper we describe the challenging process of designing PBL material for online learning in the form of a case from another culture. The research question we address is the following:

> *How is it possible to implement the basic PBL principles as applied in a face-to-face situation, in culturally contextualised online learning material provided on a digital learning platform, in a way that supports students' active learning?*

The PBL context in which we want to explore this question is Aalborg University, Denmark where PBL has been applied since the establishment of the university in 1974, while the cultural context in the learning material is Kenya.

In the next section the theoretical framework for the learning design is presented. The third section presents the Shanzu project and the implementation of PBL principles in the prototype version of the online material. The fourth section describes the lessons learned concerning use of the material, and sketches the process of review of the material, while the last section is the conclusion where we draw together some generic lessons learned and recommendations.

2 Theoretical framework

This section presents the theoretical framework applied in the design of the online learning material. This framework includes the six Problem Based Learning principles that together form the foundation for all study programmes at AAU, seen through the lens of a curriculum model consisting of the triad of knowing, acting and being and combined with the main characteristics of the flipped classroom concept. These three components are described in the following three sub-sections.

2.1 Problem Based Learning

This section presents the learning theory underpinning PBL as well as the PBL learning principles, generally and specifically for the Aalborg PBL model.

In spite of the fact that some of the early Problem Based Learning models developed in the 1960'es and 1970'es do not seem to have been explicitly founded on theoretical reflections about how humans learn (Servant, 2016) today most scholars agree that PBL draws on elements of the learning theory of constructionism. Main characteristics of constructionism can be summarized as follows: Students construct their own knowledge, based on personal experiences, in collaboration with peers and through interaction with the socio-cultural environment. The focus on an authentic problem calls for change and this change may be brought about by students constructing and sharing tangible objects (Papert & Harel, 1991; Dougiamas, 1998).

Concerning PBL learning principles Kolmos & de Graaff (2014) made a comparison of the learning principles in four of the universities that first implemented PBL. The result of this comparison is shown in Table 1.

Table 1: Original learning principles at four of the early PBL universities (Kolmos & de Graaff, 2014, s. 145)

McMaster and Maastricht Universities Problem-based learning	*Aalborg and Roskilde Universities Problem-based and project organised learning*
• Problems form the focus and stimulus for learning • Problems are the vehicle for development of problem-solving skills. • New information is acquired through self-directed learning. • Students-centred • Small students groups • Teachers are facilitators/guides	• Problem orientation • Interdisciplinary • Exemplary learning • Participant-directed learning • Teams or group work
Barrows, 1996	Illeris, 1976

As outlined in Holgaard, Dahms, & Guerra, (2017), the main difference between the two sets of learning principles lies in the fact that while the principles at McMaster and Maastricht, both of which universities applied PBL in their medical schools, mainly is focused on the learning process itself, the principles at Roskilde and Aalborg, none of which had medical schools at the time, also includes the contents of learning through the focus on interdisciplinarity and exemplarity.

At Aalborg University the PBL principles have been formulated at an institutional level, in order to clearly outline the pedagogical model for study programmes (Aalborg University, 2015). The six basic PBL principles for the so-called Aalborg PBL Model are the following:

1. The problem is the starting point directing the student's learning process
2. Project organisation creates the framework of problem-based learning
3. Courses support the project work
4. Cooperation is a driving force in problem-based project work
5. The problem-based project work of the groups must be exemplary
6. The students are responsible for their own learning achievements.
   (Aalborg University, 2015, s. 5)

The most fundamental principle of the Aalborg PBL Model is that the problem is the starting point for student's learning process (P1). In the Aalborg Model a problem can be both theoretical and practical, and it has to be authentic and scientifically based. The work with the problem is organised as a project, i.e. a unique joint activity that produces a given result within a specified time limit (P2).

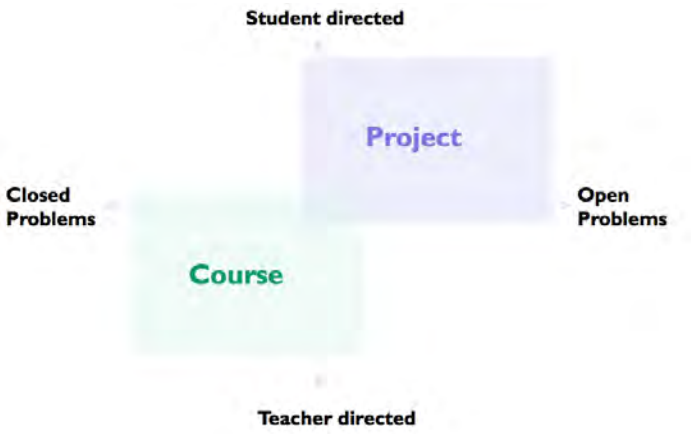

Figure 1. The combination of project work and courses characteristic of the AAU PBL Model.

The combination of projects and courses is a unique characteristic of the Aalborg PBL model (P3). Whereas the courses express a more teacher-centred and closed problem approach, the project work creates a learning space for students to explore more open problems in a self-directed manner. This is illustrated in figure 1.

Student cooperation in small groups is a common characteristic of most examples of PBL, and cooperation with a tutor, a facilitator or a supervisor is also a common feature in most PBL institutions (P4). The cooperation between students' groups and external stakeholders is, however, a unique feature of the project work at AAU, which had led to AAU being considered the best Danish university in terms of cooperation with industry and society (Nysten, 2008).

The exemplarity of the problem oriented project work is a critically important aspect of the AAU PBL model (P5), since it ensures that students acquire competences that reach beyond the university. The principle of exemplarity implies "that learning outcomes achieved during concrete project work are transferable to similar situations encountered by students in their professional careers." (Aalborg University, 2015, s. 5).

The principle of responsibility for own learning is a common feature of most PBL programmes (P6). This principle is by newly enrolled students at AAU at the same time seen as one of the most positive but also one of the most challenging aspects of their new study environment (Holgaard, Dahms, & Guerra, 2017). The degree of self-directed learning, i.e. learning that happens on the initiative of students and with students as the only participants, is quite high in AAU, in most cases close to 50%, as shown in (Dahms, Spliid, & Nielsen, 2016).

2.2 The PBL principles in a curriculum perspective

In this section we will take a look at the AAU PBL principles seen in the perspective of Barnett's curriculum triad of knowing, acting and being (Barnett & Coate, 2005). In this triad the components of 'knowing' and 'acting' are taken well care of in most engineering curricula today. The third component of 'being' is, however, often neglected, although according to (Barnett, 2007) this component represents the most important role of education today for students to develop "durable capacities for flourishing" in an ever-changing world (Barnett, 2007, s. 63) here quoted from (Brook, 2017, s. 1). According to (Brook, 2017) the 'being' may be integrated into the curriculum through such concepts as 'graduate attributes', 'transferable skills, 'process competences' etc.

In the Aalborg PBL model the component 'knowing' is represented by the courses as well as by students' self-directed active search for relevant information and by extensive peer teaching and –learning that takes place in the small groups in connection with the project work. The second component 'acting' represents active learning which is one of the cornerstones of the Aalborg PBL model and taken well care of by the project work. The third component 'being' is in the Aalborg PBL model well represented through the authenticity, contextualization and exemplarity of the problem that forces the student to take normative stands and make decisions based on her own values and attitudes.

2.3 Flipped classrooms

The use of information and communication technologies in higher education has increased dramatically all over the world during the last two decades. One way of using ICT in higher education is the so-called 'flipped classroom' approach to teaching and learning. One of the reasons why this approach is on the rise is the decrease in public funds for education which leads to reduced time for direct interaction between teachers and students, and a consequent need to increase efficiency of this time. Another reason is the calls for competences that cannot be taught nor learned via classroom lectures but have to be learned through students' active engagement with the material to be mastered (Bishop & Verleger, 2013).

A simple working definition of the flipped classroom is found in (Lage, Platt, & Treglia, 2000, s. 32) here quoted from (Bishop & Verleger, 2013, s. 4): *"Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa"*. This definition is in the authors' opinion too simplistic, since the flipped classroom – which may be implemented in a multitude of different ways – in most cases is underpinned by learning theories related to student-centred learning as opposed to the teacher-controlled teaching approach that happens in the 'normal' classroom situation. The flipped classroom most often leads to an expansion of learning activities and to a change of pedagogical methods.

Some of the most common types of study activities included in flipped classrooms, as extracted from 22 studies on this approach to teaching and learning, are the following: Small group activities (14 studies); video lectures (13 studies); home work (7 studies) (Bishop & Verleger, 2013, s. 10). In the case study described in the next section, small group activities and video lectures are part of the online learning material, while the use of home work is to be decided by the teacher using the material.

In summary, the theoretical framework for the design of the online learning material is based on the AAU PBL principles, the Barnett curriculum triad of knowing, acting and being and on the characteristics of the flipped classroom approach.

3 The Shanzu case

This section first presents the engineering project that formed the foundation for the case based online learning material. The second sub-section describes the design of the prototype online learning material, with focus on how this design process was inspired by the PBL principles concerning the form of the material as well as the contents. The purpose of the online learning material, is to give engineering students access to real-life problems embedded in another cultural context.

3.1 The Shanzu project

The case used as basis for the design of online learning material is an engineering project that lasted from 2009 to 2013 and was funded by the Danish pump company Grundfos, which has a goal of delivering water solutions anywhere in the world. The project provided water and power supply to the Shanzu Transitional Workshop for Disabled Women, operated by the Kenya Girl Guides Association. The workshop is located in the small village of Shanzu on the coast of the Indian Ocean approximately 30 km north of Mombasa, Kenya, a location that means that ground water from the on-site borehole is brackish water.

The project developed over 4 phases, starting in 2009 when a Grundfos staff member – the project Manager (PM) - visited the workshop. The PM noticed the appalling water situation in the workshop where the disabled women had to haul fresh water almost 100 m from an outside tap to the kitchen and the bathrooms where the water was needed. He identified several problems related to the water situation and wrote a project description and an application for project funding to the Poul Due Jensen Foundation, named after the founder of Grundfos.

After having received a generous grant from the foundation, Phase 2 was initiated. This phase included a proactive technology assessment of possible solutions and procurement of equipment for the chosen solution. Phase 3 encompassed installation and operation of new water supply systems, one for fresh water and one for brackish water. The water supply systems included water tanks and solar driven submersible water pumps. A new power supply system, consisting of a large solar panel and an accompanying battery bank with a 220 V inverter was also installed in a new shed in the Shanzu workshop. The third phase of the project also included necessary repairs to the newly installed equipment and consolidation of the installations through training of local artisans to maintain and repair the equipment, while the final phase mainly consisted of reflections on and evaluation of the project.

3.2 The Shanzu case material

In a problem based learning environment students are to identify, analyse, formulate and solve real life engineering problems. One way of giving students access to real life problems in another cultural setting than their own is by presenting cases in which students are faced with challenges based on an authentic story of engineering practice. The Shanzu project is just that – an authentic story of real life engineering practice – and therefore is a good foundation for a problem oriented learning case. In the following we will describe how the AAU PBL principles have inspired the design of the on-line material in the Shanzu case.

The overall design of the **format** of the learning material has been inspired by the principle of courses supporting the project work (P3). This P3 principle is reflected in inclusion of two knowledge platforms, an academic knowledge platform representing the courses and a contextual knowledge platform representing the project work with the authentic contextualised problem. This is illustrated in figure 3.

Figure 3. The Shanzu material consisting of two knowledge platforms.

The material presented on the academic platform is a mix of short lectures, learning outcomes and pre-defined assignments for students to carry out. The resources found on the contextual platform are a mix of short inputs from the PM to the project process, on-site interviews with different stakeholders and photos and films with voice-over information about Shanzu, the workshop and the people there. All resources are presented with short introductory texts.

Furthermore, the learning material is divided into 4 phases, following the phases of the Shanzu project, and all 4 phases are designed as shown above with 2 platforms. Thus, students are expected to move through the learning material phase by phase, in the same sequence as the project was carried out in real life, starting with the problem identification and analysis (phase 1), technology assessment (phase 2), implementation and beyond (phase 3) and project and process analysis (phase 4).

The contextual knowledge platform offers students the opportunity to gain thorough insight in the case and thus identify, analyse and formulate problems observed by themselves. As such, the material calls for project organisation (P2), allowing the students to work on their own project design from different perspectives as self-directed learners. In this way the students are encouraged to take responsibility for their own learning (P6).

Cooperation in small groups of students (P4) is stressed in the teachers' guide and emphasised in the lecture on PBL as well. Furthermore, when students have moved through the first 3 phases of the learning material, they are asked to carry out a project and process analysis, which includes meta-reflections on the collaboration in the group. As such the design presupposes that students work in teams and that teams are facilitated locally.

Concerning the **contents** of the learning material the most fundamental PBL principle is that the problem is the starting point for student's learning process (P1). Therefore, in the first phase of the learning material students are challenged to identify, analyse and formulate problems presented in the contextual platform, and thereby learn about problem-design (Holgaard, Guerra, Kolmos, & Petersen, 2017).

Of the 6 AAU PBL principles the principle of exemplarity (P5) has no doubt been the most influential in the design of the learning material, as embedded in the contextualised frame for the students' problem based learning process. The main aim of the learning material has been to provide possibilities for students to gain experience about a long-term project carried out in cultural context different from their own. By working through the different phases of the project/the learning material students experience how decisions made at one point in time influences implementation and operation at a later stage of time. It would not be possible to achieve this kind of experience in a normal short-term project in a fixed curriculum structure.

As noted in the teachers' guide to the Shanzu case material Holgaard & Dahms, (2016, p. 1):

> *"This material is not a substitute for field studies where students experience the context in-situ. Rather, it holds the same possibilities as a flight simulator for a pilot, providing students with an opportunity to gain a strong sense of what real life engineering could be like, while still being on safe ground. It may also open a window to a cultural setting that the students would not otherwise have access to."*

Thus, the films, the interviews and the role-play of students following the Shanzu project manager (PM) through the different phases of the project were designed to provide students with a sense of real life professional engineering practice in a new cultural setting – interacting with the people they design for and referring to a project manager.

After the above description of the Shanzu project and the presentation of the design and implementation of the Shanzu case material to be used in connection with a flipped classroom approach, in the next section we will take a critical look at the prototype material, with the aim of identifying strengths and weaknesses.

4 A self-critical analysis of the Shanzu case material

The following critical analysis is based on feedback from participants in a workshop where the Shanzu case material was presented, as well as on our own work with the material over time, involving new people into the project and listening to their views on the material. Unfortunately, only very few teachers have requested the material and those who have have not come back with any evaluation of the material; thus, we do not have evaluations of the material in use.

4.1 Strengths

When designing the learning material, the intention was to create a learning platform that would expose students to authentic real-life problems in an intercultural context. As students work their way through the 4 phases of the Shanzu learning material they will experience how a problem based engineering project developed over time in a context not familiar to them. In this respect, if students work their way through all the Shanzu case material, they will get a good and useful impression of a real-life project where intercultural communication is an integrated part of the project.

The prototype Shanzu case material was presented in a hands-on workshop in the ETALEE 2017 conference (Holgaard & Dahms, 2017) and the feedback received from workshop participants was very positive concerning the format with the two knowledge platforms and the diversity of educational resources on these platforms. The actual contents of the material was, however, not so positively received – most participants said that the case contents was too far away from what they would be able to use in their own teaching.

4.2 Weaknesses

From the outset of the design process the intention has been that the learning material would be used by a teacher as part of a module, course or programme. Therefore, the material is free but not open-source since a teacher has to request access in the form of passwords to the different phases of the material. Therefore, a teacher's guide has been developed to ensure that interested teachers would know how to use the material in class. This limitation has 2 effects, the first of which is that an interested teacher would have to look through quite a lot of material (all resources in the 4 phases plus the Teacher's Guide) in order to decide upon whether to use the material or not. Another effect is that the Shanzu case is not truly e-learning but rather blended learning material that may be used in a flipped classroom situation, combining out-of-class watching of video material from both the academic and the contextual knowledge platforms with in-class discussions and group assignments, including analysis of intercultural communication and engineering problems in a context far away from the students' own cultural environment.

The intention of providing the material on an open platform was to provide access to the material for teachers anywhere in the world with an Internet connection, but probably because of the above mentioned limitation only very few teachers have requested access to the material and therefore we do not have any evaluations of how the material has been functioning in a teaching situation.

One of the major shortcomings of the prototype material is that it does not support student agency and ownership to the problem. When setting out on phase 1 material students are requested to watch the on-site videos. In the phase 1 assignment they are encouraged to identify relevant problems that they observe in these videos from the Shanzu workshop. Subsequently, in phase 2, the PM from Grundfos defines the "correct" problem, resulting in the rest of the learning material taking its point of departure in this 'correct' problem definition. This happens even if the problems identified by the students might be equally relevant. When students' answers are disqualified in this way, not because of a lack of academic foundation but because they did not match the 'correct' problem identification, this might result in students feeling a lack of ownership to the problem and the project, thus becoming demotivated.

Another weakness in the material is the lack of real-life complexity. In section 3.2, we emphasised the four phases of the project: Problem Identification (phase 1), technology assessment (phase 2), implementation and beyond (phase 3) and project and process analysis (phase 4). The learning material follows a sequential linear structure of problem solving. In a real-life project the problem-solving process is considerably more complex, with several feedback loops between the different phases. The technology assessment, for example, might give rise to new insights that would necessitate a change of the definition of the relevant problems that the students wish to solve. In the Shanzu case, the students are not encouraged to go back, but are supposed to follow the linear phase-by-phase approach of the problem solving process, resulting in a simplified problem solving process, that does not reflect real-world complexity.

Although the intention from the outset was to make the learning material flexible, so that different parts of the material could be used in different types of learning contexts (study levels, study areas etc.), this flexibility has only been achieved to a limited extent. As mentioned above the problem is the starting point for the learning process in PBL and the 'correct' problem is introduced immediately after phase 1. The subsequent phases all take the point of departure in that problem, making the material somewhat inflexible. Another lack of flexibility concerns the engineering contents in the learning material, i.e. water supply, solar energy and electricity supply, which may not be relevant fields of study for very many students.

After the critical analysis of the prototype learning material above, in the last section an attempt is made to present recommendations for modification of the material and to draw a conclusion to the paper.

5 Recommendations and conclusion

Future work with development of the online learning material will be based on the experiences and the critical analysis above, and the development will be carried out according to two different strategies.

The first strategy is based on the positive feedback from the ETALEE workshop participants concerning the format, i.e. the two platforms and the variety of resources on the platforms. According to this development strategy an 'empty' platform is to be developed that will allow teachers – and possibly students as well as suggested by one of the workshop participants – to fill in contents into a pre-designed template similar in format to the Shanzu platform. Developing a software platform that will allow for such customized flexibility in terms of contents will be a considerably bigger and more costly project and will need more IT expertise than what was available in connection with the prototype development.

The second strategy is to use the existing material but to package it in much smaller packages with no forced interdependence and with more clearly specified aims and learning outcomes. One such package might contain material where students work through 3 phases of learning: Getting aware (of the problem); knowing more (about the problem); doing more (in relation to the problem). During the 'getting aware' students familiarize themselves with the problem context, during the 'knowing more' phase they study relevant sources of information in form of lectures, articles, text book and Internet home pages to increase their knowledge about the problem and the context, and finally, in the 'doing more' phase they work with assignments and problem solutions that do not have a 'correct' answer but will be open to critical discussion in class with other students groups and with the teacher. A few examples of such packages could be "Problem design", "Technology assessment", "implementing technology in an intercultural context", where bits and pieces of the present Shanzu case material can come in and be used effectively. Development according to this second strategy is presently ongoing.

In conclusion, the 2 main lessons learned until now are the following:

- Trying to design material that targets everybody often ends up becoming material that targets nobody
- Using a historical project as basis for a pro-active PBL learning material does not work – you cannot honor the history and at the same time give students the freedom to direct their own learning.

When looking back at the process of developing the prototype Shanzu case material, at a very low budget and without sufficient expertise on development of online learning material, we have learned a lot, maybe more about what does not work than about what works, but the process has nevertheless been a fascinating journey through a fascinating project played out in a cultural context so very different from our own, and we are grateful to all the people, in Shanzu as well as in Grundfos, who made this journey possible.

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A curricular innovation in the teaching of Calculus in engineering programs

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Abstract

The initial Differential and Integral Calculus course in most Brazilian engineering programs has high failure rates, posing a bottleneck that increases both students' demotivation and evasion. One of the main causes of this phenomenon is the pedagogical approach usually taken, one which values technique over the fundamental ideas of Calculus and overemphasizes mathematical formalism. In this work, we present a curricular innovation that was introduced into three new engineering programs, which started in 2015. This model was designed such that the students' first contact with Calculus happened in a course called Modelling and Simulation of the Physical World, which is project-based. By creating models for dynamic systems, which can be described by difference and differential equations, the students deal with the notions of mean rate of variation and instant rate of variation in numerical and graphical contexts. Technical aspects, such as the algebraic calculation of different types of derivative functions, and the mathematical formalization, such as the precise definition of limit, are only dealt with in the following semester, in the Mathematics of Variation course. Calculations are performed numerically and relate to real situations, favoring the creation of meaning around the notions of derivative and integral. Two aspects have been considered to evaluate the effects of the described model on students' mathematical learning, both of which were assessed in the Mathematics of Variation course. The first was the failure rate, which was compared to those of initial Calculus courses in other Engineering programs. The second was the students' intrinsic motivation, which was compared to that of other courses within the same program. In both aspects, results suggest that the adopted model had positive effects on students' learning.

Keywords: Differential and Integral Calculus, engineering education, innovation, modeling, fundamental ideas.

1 Introduction

Many researchers have dedicated themselves to study the problems faced in introductory Calculus courses in Brazilian higher education (Mello et al., 2002; Rezende, 2003; Lima, 2015; Henning et al., 2015), reporting high failure rates, ranging from 45% to 95% in some universities. The terrible results observed in Calculus contribute decisively to the high dropout rates observed in Engineering programs in Brazil, which vary between 40% and 45% in public universities and reach 70% in private institutions (Campos, 2012). This scenario shows that the course of Calculus is a bottleneck for science, technology, engineering and mathematics in undergraduate programs.

According to Bonomi (1999), the approach adopted in this discipline is very similar to that of an Analysis course, in such a way that the concepts are presented in a "*formal, logically well-structured context in which the concept of real number is preponderant and the study of functions appears as an end in itself*". Although such an approach makes sense from a mathematical point of view, it does not highlight the fundamental ideas of Calculus, such as variation and approximation. The creation of meaning related to the central concepts of Calculus - derivatives and integrals - is impaired. As a consequence, students divide their attention between dealing with excessive mathematical formalism and memorizing calculation procedures, failing to perceive applications for that knowledge, which generates high levels of frustration and demotivation.

The fact that the high school curriculum in Brazil does not address the ideas of Calculus, even at an introductory level, only aggravates the situation described above. Bonomi (1999) points out that, "*for most students, mathematical knowledge developed previously in secondary school has little or nothing to do with what is presented to them in the course of Calculus*".

All of these issues were discussed during the design of the three new Engineering courses (Mechanical, Mechatronics and Computing) at Insper, in Sao Paulo, Brazil (Soares, Achurra, & Orfali, 2016). Considering how engineers use and learn to use mathematics in their practice (Cardella, 2008), it was agreed among faculty members involved in the project that the traditionally adopted model of teaching Calculus in Brazilian engineering schools should not be replicated in the new programs.

Thus, two assumptions were established for the area of mathematics in the curriculum of the three courses. First, mathematical formalism and the teaching of techniques could neither precede nor eclipse the learning of the central ideas of Calculus. Secondly, the motivation for the study of mathematics should come from real problems of engineering. In other words, students should not spend the early years of the program just accumulating context-free mathematical knowledge to be applied in real problems only in the later years.

In order to implement the ideas described, most of the mathematical content was organized into three disciplines, routed in the first three semesters of the program. In Modelling and Simulation of the Physical World (ModSim), students deal with the ideas of variation and approximation to create mathematical models that represent physical systems. In this course, notions of derivative, differential equations and numerical integration are addressed, without an emphasis on mathematical formalism or analytical techniques. In Mathematics of Variation, one of the learning goals is related to obtaining analytical solutions of differential equations and systems of differential equations. Therefore, students learn the main tools of single variable Differential and Integral Calculus and Linear Algebra. Finally, the syllabus of Multivariate Mathematics includes Calculus of several variables and Vector Calculus.

The expected learning outcomes of this paper regard impacts in failure rates and student motivation in the formal study of Differential and Integral Calculus due to the introduction of ModSim one semester before, which constitutes one of the curricular innovations of Insper Engineering courses. In the next two sections, the course is described in more detail considering both its more general aspect and the mathematical concepts involved.

2 Modelling and Simulation at Insper

2.1 Course framework

ModSim is a course taught in the first semester of engineering at Insper. Originally created at Olin College of Engineering (Olin, 2017), in Massachusetts, the course was adapted to the Brazilian context in the beginning of 2015. As its 2014 edition at Olin, ModSim at Insper has been an interdisciplinary course, in which physics, calculus and programming are simultaneously employed on a completely project-based approach. ModSim's main learning objectives regard students' capabilities of applying processes for modelling and simulation of physical phenomena, employing programming tools and computer simulation, and developing abilities of oral and visual communication about their models, corresponding assumptions, results and conclusions.

In a nutshell, the course consists of three projects that must be implemented in four months, and in each one of them the modelling and simulation framework must be followed by the students. The first project constitutes a trophic cascade problem, in which students are required to design, implement, simulate and validate a model for predicting changes in populations of sharks, rays and scallops, based on stock and flow models and difference equations. The second project regards two subjects, one of which must be chosen by the students: thermodynamics and pharmacokinetics. In each of these subjects, students are required to work with stock and flow diagrams and first-order differential equations. Lastly, in the third project, students must choose a mechanical problem of their interest, in which free-body diagrams related to second-order differential equations should be employed to predict positions and velocities in time. While the first project in done individually, the second and third projects are done in pairs.

The first project is conceived to have a more scaffolded framework than the other two. Brazilian students are generally unacquainted with project-based learning, and that implies the necessity of devising a well-structured calendar of readings, activities, deliverables and exercises students are required to turn in at specific dates. ModSim was designed to consider increasing levels of students' autonomy throughout the course, what tends to increase their intrinsic motivation in learning specific content they need for solving problems (Black & Deci, 2000). In the first project, the level of autonomy is relatively low, since all the students work on the same subject and are required to follow a strict schedule. Nonetheless, they can choose different approaches on modelling their trophic cascade, including simplifications and assumptions for which they are required to present a justifiable explanation. The level of autonomy grows considerably in the second and third projects, when students must choose subject matters they find more interesting or useful, even though they are still required to follow a macro schedule.

It might be interesting to mention that the course counts on studio classes, in which students have time to discuss their projects with the professor and assistants. Although very flexible, some of the studio classes are specifically devised for students to rehearse their presentations and the effectiveness of communication, including reasonability of explanations and justifications for decisions made along the modelling steps. In the end of each project, students are required to deliver a five to seven-minute presentation in front of the class, generally with the presence of sophomores and, occasionally, other faculty member. Each student is assigned to a presentation block, in which a number of peers are assigned to evaluate and comment on presentations. Assistants and professors comment on every presentation and these comments become the main source for students' assessment and grading, done via rubrics concerning the quality of the model, effectiveness of results and quality of communication.

2.2 Modelling physical problems

The modelling and simulation framework follows a simplified version of the scientific method, which, according to the Oxford Dictionaries, is a "… *method of procedure that has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses*" (Oxford, 2017). Therefore, ModSim's framework consists of the following three processes: i) ideation, in which questions are asked about a system, phenomenon, machine or whatever real-world event has been the focus of the study. Ideation also consists of hypothesising about equations, mathematical relationships, simplifications, the use of diagrams that can describe specific features of a general phenomenon and so on. Students are also taught how to do scientific research considering academic sources and peer-reviewed databases; the second process in the framework is the ii) implementation and simulation of the model using programming language and mathematical tools. In the simulation step, the strategy is to start with a simple model and iterate into a more complex one, which can completely change equations and diagrams devised at the ideation step. Finally, the discipline's framework considers iii) the validation of results, either through experiments or published scientific research, in which explanations and predictions can be confronted with real data or physical laws.

The described modelling steps must be followed by the students during the conception and realization of the three projects. It might be useful to mention that students can attain high levels of understanding in completely different subject matters depending on their choices along the projects. For instance, optional introductory lectures on thermodynamics, pharmacokinetics and mechanical systems are offered to students after they choose the topic they wish to work with in the second and third projects. Even with the expected greater level of autonomy for the last two projects, students are constantly required to check in with professors, who can evaluate student's choices, levels of complexity, oversimplifications, programming codes and so on.

2.3 Programming and data visualization

Since the beginning of the course, students are introduced to Python as a programming tool for simulating dynamical systems and implementing general numerical calculations for the simulation step of their projects. It is important to mention that ModSim counts on another first-semester programming discipline called Software Design, in which Python is taught as the main programming language.

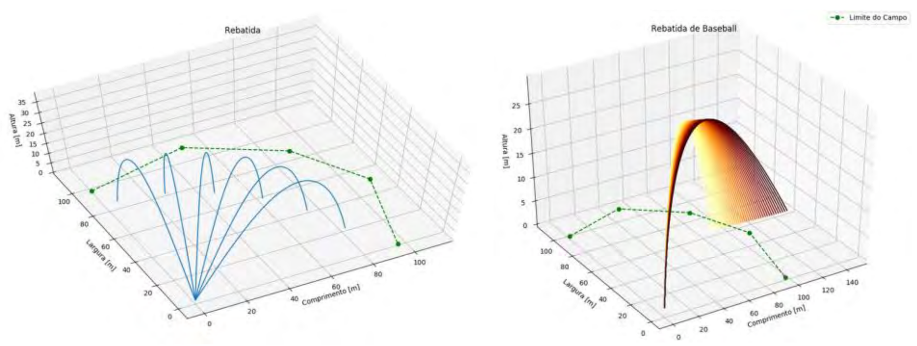
In the first project, students are required to use basic concepts of programming, like lists, arrays, loop structures, simple functions, and mathematical and graphing modules in Python (Python, 2017). Since the main goal of this project is to predict or explain populations' changes over time, students can deal with simple data structures to account for incremental changes in interrelated difference equations regarding a three stock trophic cascade. As mentioned before, in the second project students are required to choose between two different subjects: thermodynamics and pharmacokinetics, which must be dealt with using stock and flow diagrams and first-order differential equations, which in turn must be numerically solved using ODEINT (Scipy, 2017), a module for numerical solution of differential equations in Python. In terms of programming skills, the second project represents a considerable step forward for students, since ODEINT requires the use of arrays, function pointers and time lists.

In the third project, in which students are required to work with mechanical systems, ODEINT is used for integrating second-order differential equations. At this point in the course, students dominate the essential knowledge and can concentrate in more advanced programming features, such as animation, 3D graphing and more sophisticated data structures. By the end of the third project, it is remarkable to observe the progress students have had from day one, remembering that the great majority of students had not had any previous experience in programming.

As stated in 2.1, one of ModSim's learning objectives is developing abilities of communication (oral and visual) of arguments on scientific grounds. Students are required to prepare presentations and posters than can be used to support the explanation of their model assumptions and simplifications, equations and diagrams, and validation and results. Usually, presentations start with a question about the object of study, followed by details on the ideation of the model, simulation, validation and, lastly, a figure of merit that sums information up in an efficient graph, which generally shows ranges of possible solutions that answer the question posed at the beginning.

Evolution is remarkable in presentations regarding the second and third projects, which shows evidence that students effectively learn by doing (Hmelo-Silver, 2004). **Error! Reference source not found.** shows 3D graphs presented by two students in the end of their third project in May of 2016. Their goal was to study the effect of initial velocity and spin of a baseball in its range and trajectory.

Figure 1. Students presented 3D graphs for explaining the effect of initial velocity and spin of a baseball hit. The graph on the left shows trajectories for different angles of hits, and the one on the right shows trajectories for different angular speeds inflicted on the ball.



3 Math in ModSim

The students' first contact with math contents in ModSim happens through stock and flow diagrams, functions described by polynomials and difference equations in the modelling of population growth, the theme for the first project. The approach taken is completely discrete, and rates of change are implicitly considered with a discrete unitary time-step (generally one month or one year). Since Brazilian students do not have differential calculus in high school, experience has shown so far that when freshmen work with discrete problems in the first project, they seem to better understand the concept of rates of change and absolute levels of variables in time.

Calling $P(t)$ the size of a given population at an instant t, which can only vary by unitary increments, the growth of P can be modelled by the difference equation

$$P(t+1) = P(t) + \Delta P \quad (1)$$

Time t is usually measured in months or years and ΔP is the rate of variation of P in regard to a unitary increment in time t, i.e., ΔP is, usually, the monthly or yearly change in the population. This rate may depend upon different factors, like birth, death and predation rates, availability of food, the size of the population itself and many others. By using difference equations and the notation ΔP, the goal is to make students understand that the focus is the variation of the population and how to represent it mathematically.

In order to determine an analytical expression for ΔP, students are encouraged to use stock and flow diagrams. On such diagrams, the broader arrows represent the population changes and the thin arrows represent the influence of stocks over these changes.

Instead of focusing on the analytical solution of the difference equations, students solve them recursively with lists and loops in Python, with which they can graph solutions (time-series) to the difference equations related to their trophic-cascade problems. Students are also encouraged to find analytical solutions to difference equations that can be interpreted as simple geometric progressions. In both cases, students must understand the need to know the value of the population at a given instant of time, usually $t = 0$, in order to solve the equation, which is the essence of the initial value problem.

The second project starts with pre-readings followed by studio classes in which students begin to deliberate about how to decrease the initially unitary time-step into a much smaller one in accounting for problems where rates of change vary in real-time. The notation $\frac{dP}{dt}$ is introduced and difference equations gradually turn into differential equations when students are faced with the concept of instantaneous rates of change that depend on variables and parameters of the problem. At this point, students learn how to numerically calculate the derivative of a series of points by graphing them and interpreting the derivative as the slope of the line which passes through two consecutive points.

Then, in order to explore this new tool, the second project focus on continuous phenomena, that is, heat transfer and the flow of a drug along different parts of the body. In both cases, students are again encouraged to use stock and flow diagrams to help deriving the equations. Even though the modelling is that of a continuous phenomenon, the analytical solution is still not a goal. Instead, the recursive method that was being applied before is refined to allow for non-unitary changes in time, leading to Euler's method. By doing this, the derivative is taken to be approximately constant along each of those time intervals, but not necessarily the same on every interval. The original difference equation (1), then, becomes:

$$P(t+\Delta t) = P(t) + \left(\left.\frac{dP}{dt}\right|_t\right) \cdot \Delta t \quad (2)$$

Notice that the value of the rate of change along each interval is taken in respect to the initial instant of the interval.

Again, the focus is neither obtaining the analytical solution, nor developing advanced numerical methods to solve the equation. Euler's method is presented due to its simplicity and so that students have a grasp on how the computer will solve the equations, which will be done with the aid of ODEINT and its powerful Runge-Kutta numerical methods, but the method itself is merely illustrative.

As a side note, it might be interesting to point out that the pharmacokinetic model is retrieved during the course Mathematics of Variation, which is offered the next semester. The model serves as background for the analytical study of systems of differential equations and the role of matrices in solving them.

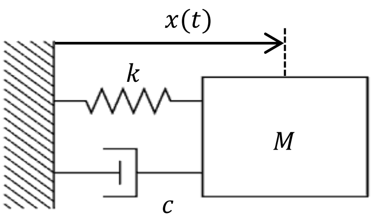
Since the third project is dedicated to mechanical phenomena, the students need to understand the concept of the second derivative, i.e., a rate of change of a rate of change, which is closely related to the acceleration of a body. The geometric interpretation, i.e., the curvature, is not emphasized, but the concept of derivative as a function becomes central: by establishing the rate of variation on each point, the rate of variation itself is a function and, thus, can also have its derivative calculated.

Then, after this concept is introduced, second-order differential equations arise as a natural consequence of Newtonian mechanics. In contrast with the previous two projects, stock and flow diagrams do not play a major role in the physical modelling, since governing equations are derived from well-established laws of Physics.

At this point, students are faced with another problem: how could one solve a second-order differential equation if ODEINT (and similar functions in other programming languages) is only able to tackle systems of first-order differential equations? Students are presented with a strategy of algebraic manipulation: any second-order differential equation can be broken into a system of two first-order differential equations. In the specific case of dynamics, this strategy has a particularly interesting interpretation: one of the equations models the rate of change in speed while the other models the rate of change in position.

Figure 2 shows an example of physical modelling, the classic mass-spring-damper system. Newtonian mechanics allow for the derivation of a second-order differential equation that models the position of the mass over time. This equation is then transformed into a system of two first-order differential equations.

Figure 2. The mass-spring-damper system, the second-order differential equation that models the position of the block over time and the corresponding system of first-order differential equations



$$\frac{d^2x}{dt^2} + \frac{c}{M} \cdot \frac{dx}{dt} + \frac{k}{M} \cdot x = 0$$

$$\begin{cases} \dfrac{dx}{dt} = v \\ \dfrac{dv}{dt} = -\dfrac{c}{M} \cdot v - \dfrac{k}{M} \cdot x \end{cases}$$

On this modelling, M is the mass of the block, k is the elastic constant of the spring, c is the damping coefficient of the damper, $x(t)$ is the position of the block over time and $v(t)$ is its speed over time.

To ensure that students do not fall behind with the learning goals, they take diagnostic exams, which intend only to reveal their level of proficiency and are not a part of the grading mechanisms. This way, professors can address individual learning issues more adequately.

Mathematical knowledge built in ModSim is directly linked to covariational reasoning, which is described by Carlson et al. (2002) as "*the cognitive activities involved in coordinating two varying quantities while attending to the ways in which they change in relation to each other*". We concur with these authors' view that learning the fundamental ideas of Calculus relies substantially on enriched covariational reasoning abilities.

Thus, the main mathematical-related ModSim learning outcome is the development of students' covariational reasoning, considering the theoretical framework proposed by Carlson et al. (2002). Specific tools used in the assessment of this learning goal are described in Orfali (2017).

4 Preliminary results about the impact of ModSim on the learning of Calculus

In the end of 2016, the second class of the new engineering programs at Insper finished the Mathematics of Variation course. When taking stock of the first two versions of the course, there was a clear impression among professors that most students' relationship with the learning of Calculus was quite different from that of most engineering schools in Brazil. The students' motivation to learn mathematics, well above average, was not only attributed to the structure of the Mathematics of Variation course itself, but also to their experience one semester before, in ModSim.

In this context, evidence was searched for to corroborate the professors' impression, in order to assess the Calculus teaching model that was designed two years earlier. This task by itself is quite complex, since it involves the comparison of students from different institutions, with different mathematical backgrounds, and who were not evaluated by the same instruments. In addition to that, there was no previous planning to collect such evidence. That is the reason why only available data on the literature and data regularly collected at Insper were analyzed.

Even with the abovementioned limitations, it was considered that the available data could point out paths for further studies, focusing on aspects that are more specific to the teaching of Calculus in engineering programs. So, in order to allow for external comparison, the failure rates of Mathematics of Variation at Insper and Calculus 1 at other institutions, which were available on the literature, were analyzed. On the other hand, as a complementary tool for assessing outcomes, an internal motivation survey was also considered, one which students have made in each of the five courses in the second semester, Mathematics of Variation among them.

4.1 Failure rates

Even with the documented problems about the Calculus 1 course on engineering programs, the amount of studies dedicated to this course in Brazil is not vast. For instance, from 2003 to 2012, only 1,6% of the papers on the Brazilian Congress of Engineering Education (Cobenge) were dedicated to this theme (Wrobel, Zeferino, & Carneiro, 2013). So, the available quantitative data about the failure rates in Calculus 1 is scarce in comparison to the amount of engineering programs in Brazil. Nonetheless, consensus about the dire situation of the learning of Calculus on engineering courses allows affirming that this data represents well most Brazilian institutions.

Data available in literature (Bonomi, 1999; Rezende, 2003; Wrobel, Zeferino, & Carneiro, 2013), referring to engineering programs in Brazil, indicate extremely high failure rates in the initial Calculus course, ranging from 30% to 83%. These data contrast with the observed rates in Mathematics of Variation at Insper from 2015 to 2017, which were 15%, 20% and 17%, respectively.

4.2 Intrinsic motivation

At the end and in the middle of the school semester, the team that coordinates Insper's engineering programs evaluates students' motivation in each of the five courses. This is done through a 12 question survey and the answers are interpreted according to the Situational Motivation Scale (SIMS), an instrument used to measure an individual's state of motivation at a given instant of time (Guay, Vallerand, & Blanchard, 2000). The motivation evaluation shows a complimentary aspect in regard to the analysis of failure rates because, even though it addresses different courses, it is applied to the same set of students, which share the same educational experience.

Each question relates to one of the four following states of motivation: amotivation (A), external regulation (ER), identified regulation (IR) and intrinsic motivation (IM). Answers are given on a 1 to 10 scale, which generates an average value for each state. Based on those averages, the Self-determination Index (SDI) is calculated using the formula:

$$SDI = 2 \times IM + 1 \times IR - 1 \times ER - 2 \times A \tag{3}$$

Therefore, the SDI evaluates the motivation state of an individual in a continuous interval, in such way that higher values refer to a greater enthusiasm, generated mainly due to internal factors, and lower values are associated with higher levels of demotivation. Table 1 shows the SDI for the students in the second class of Insper Engineering (2016) on the five courses of the second semester. Data is not filtered by program because, until the end of the first year, students are not divided in groups according to the their programs.

Table 1. Self-determination Index (SDI) in the five courses of the second semester in Insper Engineering programs (2016).

Course	Mathematics of Variation	Physics of Movement	Electrical Drives	Data Science	Co-design of Apps
SDI (middle)	7,00	1,73	5,13	2,75	4,48
SDI (final)	8,23	3,81	4,61	4,98	4,64

5 Conclusion

The results shown in section 4, despite the need for further investigation, suggest a very interesting path for the teaching of Calculus in engineering programs. In Brazil, where Calculus is not part of the secondary school curriculum, this path seems even more promising. Failure rate comparisons between institutions, although anecdotal and limited, could be considered evidence for the needed additional research on the matter.

In the designed model, students' first contact with Calculus occurs in a project-based course, in which the fundamental ideas of this area of mathematics are discussed through the modelling of real systems. Evidence indicates that the experiment contributed significantly to students' motivation to learn Calculus. The performance of these students regarding the failure rates in the following semester, in which mathematical formalism and Calculus techniques began to be incorporated, was much superior to what has been reported in the literature.

A natural sequence of this work is the construction of a theoretical model that better explains the mathematical development of the students during the course of ModSim. The most appropriate starting point for this would be the covariational reasoning model, mentioned in section 3.

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PBL methodology in Business Administration and Industrial Engineering and Management Programs: similarities and differences

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Abstract

PBL has been implemented in many programs in the universities as a need to change pedagogical and learning practices from teacher-centred to student-centred methodologies. Business Administration from Brazil, Instituto Federal de Educação, Ciência e Tecnologia Fluminense and Industrial Engineering and Management from Portugal, Department of Production and Systems, University of Minho are two of such programs. PBL implies an innovative curriculum design that could assume many forms and be differently implemented. The aim of this paper is to describe these two different approaches of PBL, namely, focusing the differences related to: the program where was implemented, the coordination and organization, the courses implied, the teamwork organization, the assessment methods (e.g. formative, summative, self and peer), the related situations concerning implementation and development of PBL as learning approach (e.g. difficulties) and the final products expected from the project among others. Benefits for the students and teachers are also discussed in each PBL implementation. The instruments of the research methodology used were the experience of the authors, the documental analysis and the results of the students and teachers perceptions questionnaires by the project ending among others. This will give the opportunity for the authors and others researchers benefit from the best of each approach.

Keywords: Active Learning; Project-Based Learning; Industrial Engineering and Management Education; Business Administration.

1 Introduction

It has been a concern of several Higher Education Institutions (HEI) to provide, beyond technical competencies, transversal competencies such as communication skills, project management, critical thinking, and problem-solving skills, among others. This concern is driven by the demand for professionals (such as engineering and business administration) with deep and solid interdisciplinary competencies. According to Rychen & Salganik (2001), competencies is a concept broader than knowledge and skills because it implies cognitive but also motivational. Ethical, social and behavioural components in order to fulfil complex demands and tasks by the individuals. According to the same authors, "acquiring competencies is viewed as an-going, lifelong, learning process" (p.8) and could occur in multiple and different settings from the school to the cultural life. As such, learning environments that promote competencies acquisition and learning meaningfulness is preferable.

Such meaningfulness environment could be enabled by active learning approaches. Project work, in particular, as previously referred in seminal works of (Dewey, 1916; Kilpatrick, 1918) is a suitable methodology to prepare autonomous, independent and responsible citizens for their active practice social and democratic modes of behaviour. The project work have been attracting more or less interest along the years (Knoll, 1997). Nowadays, a project work methodology well-known is Project-Based Learning (PBL) that is in a higher level of attraction with a lot of Engineering programs implementing this and it is a student-centred learning methodology (Guerra, Ulseth, & Kolmos, 2017).

Attending to this, in Industrial Engineering and Management of School of Engineering of University of Minho PBL has been implemented since 2004_05 in the first year. Currently, it is in its fourth edition. Adopting a PBL model of Powell & Weenk (2003), first results of this implementation was published in 2007 by Lima, Carvalho, Flores, & Van Hattum-Janssen (2007) but since then a lot of changes have been taken place to in order to better respond to teachers, students and researchers concerns. Such feedback have been important to manage difficulties of this learning process (Alves et al., 2016b) and to integrate curricular units contents for the best learning of students (Alves et al., n.d.).

In the case of Business Administration (BA), the PBL approach was first adopted in 2015 in an Entrepreneurship course where Brazilian students developed a business plan for a floor-ball business marketing share based in a business proposed by students from ProAkatemia, an entrepreneurship program from a University of Applied Science in Finland. In the year that followed, other students from the same program were challenged to develop a business project concerning a theme from their choice. At this time the project chosen was a Food Truck business plan. It is important to highlight that food truck was not a social common concept at that time and the experience was more immersive, resulting not only a business plan but a team of students that have opened a business in a city mall (Uebe Mansur, Ryymin, Joyce, & Ruhalahti, 2016).

Despite different programs, the same concern was under the need to change the learning methodology and same problems and difficulties were faced. As so, this paper intends to present the organization and coordination of these two programs in different contexts and countries. Namely, the courses implied, the teamwork organization, the assessment methods (e.g. formative, summative, self and peer), the difficulties and the final products expected from the project are presented. Benefits for the students and teachers are also discussed in each PBL implementation.

The paper is divided in five sections. After this first introduction where the objectives are presented, the second section presents the research methodology. The third section introduces and describes the study context. The fourth section presents the main part of the paper: the comparison between the projects structures. The conclusions are shown in the fifth section.

2 Research methodology

To achieve the objective proposed for this paper, some questions were raised by the paper authors in order to be answered and to have the results of the comparison of the project structures. It was intended to know how different these projects are, difficulties felt in each, learning and competences acquired. As so, the main research questions were:

- What differences exist between IPIEM11 and BA project?
- What difficulties and/or challenges were felt in each?
- What are the differences in a transition from traditional classes' semester to a project semester?
- What competences were developed in each project?
- Have these projects structures been benefiting the students learning and motivation?
- Are students and teachers satisfied with PBL?

To answer these questions, the papers´ authors resorted to their experience, consulting all the documents that support the projects: "project guide" in the case of IPIEM1, the reports and presentations produced during the projects, the survey results done to students, teachers and tutors and registered in the papers published every year about this experience (Alves & Leão, 2015). Also, in the case BA project, the base for the information was the author experience of the project realisation, associated with the database from the Trello software (used as a platform for team meetings and data collecting as a report), videos, photos and the final presentation and also references from previous published research.

3 Study context

This section is divided in two subsections related to contexts of the Industrial Engineering and Management (IEM) program from Portugal and the Business Administration (BA) program from Brazil.

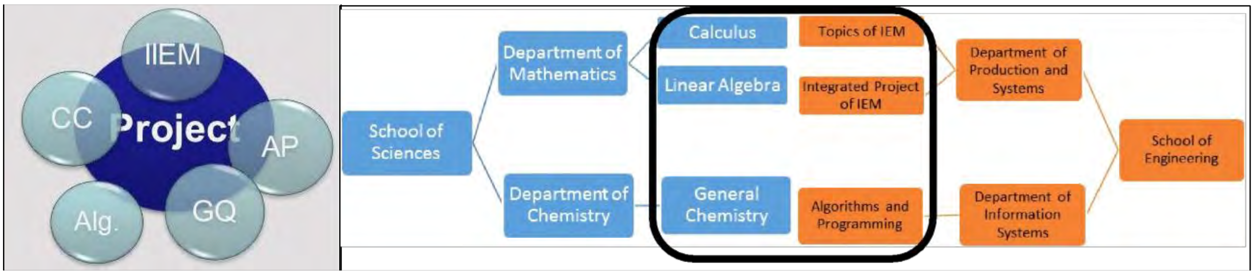
3.1 Industrial and Engineering Management

The Industrial Engineering and Management (IEM) is a five-year Master Integrated program (ten semesters) with 300 European Credits Transfer System (ECTS) ministered by the Department of Production and Systems (DPS) of School of Engineering of University of Minho. ECTS is an instrument adopted by Europe after Bologna process to facilitate the comparability of degrees in Higher Education in the European space (46 countries). One ECTS represents, normally, 25-30 hours of student work.

The main goal of this program is to train professionals with technical and scientific knowledge which are able to guarantee a competitive performance of the production systems in the companies they are working in. The program features the acquisition of specific skills which will allow the graduates to apply engineering methods and scientific management principles to production systems of goods and services, aiming at a more effective integration and coordination of management processes in the company, by combining the different types of resources (human, material, technical, economical and information services). The core areas of the DPS are: Human Engineering, Systems Engineering, Engineering and Industrial Management, Economic Engineering, Statistics, Operational Research, Numerical Methods, and Optimization.

PBL is implemented in this program in the first semester of the first year and fourth year and second semester of fourth year (Alves & Leão, 2015). In this paper just the PBL of first year that will be called here as IEM11_IPIEM1 is explained that is frequented by an average of 48 freshmen students every year. Till now a total of 14 editions (since 2004_05) were accomplished with, approximately, 620 students enrolled.

The PBL of Industrial Engineering and Management first year, first semester (IEM11) is developed in the curricular unit called Integrated Project of Industrial Engineering and Management 1 (IPIEM1). The Figure 1a) presents the Project Supporting Courses (PSC) that support the project developed in IPIEM1: 1) Topics (or Introduction) of Industrial Engineering and Management (IIEM); 2) Algorithms and Programming (AP); 3) Calculus (CC); 4) Linear Algebra (Alg.) and 5) General Chemistry (GQ). The first two are from School of Engineering as also IPIEM1 and the other three from School of Sciences as represented in Figure 1b). Each course is of five ECTS.



a) b)

Figure 1. a) PBL model of IEM11 (IEM11_IPIEM1); b) Schools and departments involved in the IPIEM1 (Alves & Leão, 2015).

Before the year of 2012 there was not a course called IPIEM1 and the project existed just based on the courses as explained in Alves et al. (2014). Currently, all five courses are PSC but there were some years when this didn´t happen, being just four courses supporting the project, namely, IIEM, AP, GC and CC. Teachers, tutors and, in some years Education researchers were part of the team coordination responsible for the preparation of the IPIEMI1. In average, this team could have 10 members (Alves et al., 2015).

Every year, there is special care in the definition of the project theme. The theme should be interesting, motivating and challenging and, at the same time, integrate the courses contents. The theme is an important motivational element in the development of the project, and therefore also in the acquisition of technical and transversal skills (Moreira, Mesquita, & van Hattum-Janssen, 2011). The themes address relevant problems in the real world, enhancing the involvement of teams in developing their own vision on the subject and building the best possible solution to the challenge posed. The specific themes addressed in the various editions always related with sustainability issues (Colombo, Alves, Hattum-Janssen, & Moreira, 2014; Colombo, Moreira, & Alves, 2015) could be seen in Alves et al. (n.d.).

The teams design the product and its production system. An example of a designed production system with the production factors, production process and product developed by a student's team in the context of each course of the edition 2016_17 is presented in Figure 2. In this edition the project was remanufacture of fashion accessories, e.g. hand cases, shoes, tights, etc.

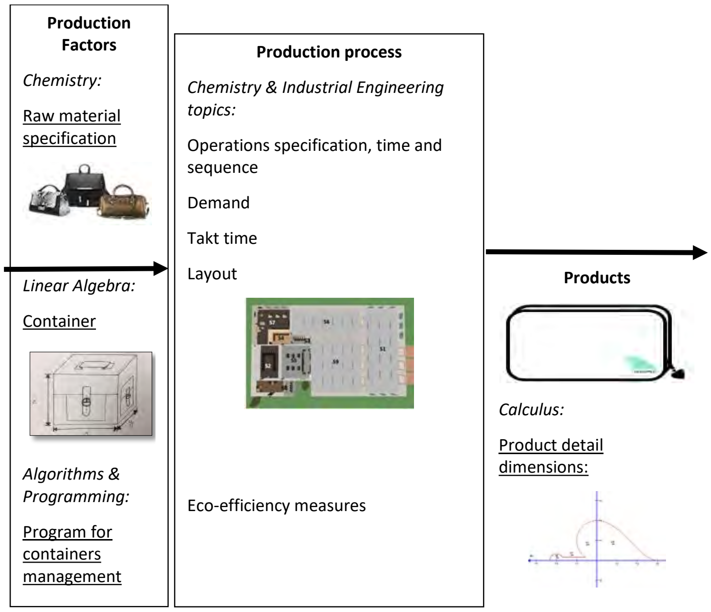


Figure 2. The production system designed by a student's team for the remanufacture of fashion accessories (2016_17 edition)

Attending to the room projects available for the IPIEM1 teams, just six teams of students are organized every year. Each team has a tutor that could be a teacher in this year of the semester or not. In the last edition, voluntary students from the third year were also tutors (Alves, Moreira, Leão, & Teixeira, 2017). To the teams is provided a learning guide ("project guide") describing the learning outcomes, the assessment model and all activities to do for accomplish the project. Six milestones consisting, in three presentations, two reports and production systems and/or product prototypes are required for the coordination team monitoring and assessing the teams' progress. The assessment model is composed of two main parts: 1) team project grade resulting from the presentations, reports and prototypes, and 2) individual grade. Individual grade results from peer assessment (Alves, Moreira, & Leão, 2017) and a written test about the final report of the project (Moreira et al., 2017).

3.2 Business Administration

The Business Administration (BA) program is a regular four-year degree related in a private university in Brazil where one of the authors is a teacher. According to the Brazilian academic rules, the business administration programs in the context of degree programs, need to offer a minimum of 3.000 hours student work, being that a maximum of 20% of those hours in extra-class professional practices (MEC/CNE/CES, 2007). The related program has 3.400 hours including 300 hours of mandatory supervised internship.

The main knowledge fields associated to the administration profession are finances, human resources, marketing, strategy and accounting (Costa, Lima, & Andrade, 2008). Despite these fields are interconnected, usually the students get contact to these academic fields separately in courses as blocks of knowledge. As reported by Uebe Mansur, Biazus, Carvalho, & Melo (2013), this disassociation among academic fields further a disassociation between theory and practice is a contributor to a non-complex learning environment what means effective decreasing in the student learning process.

The PBL is a learning approach to promote student-centred learning philosophy. From this conception the universities are increasingly seeking to apply the PBL in their academic curriculum as a way to promote student's application of theories, also skills related to creativity and innovation (Shekar, 2014). From this context and from the personal training experienced by one of the paper's authors, the PBL was adopted as a learning approach in the Entrepreneurship course of the Business Administration program in the related Brazilian university.

The Entrepreneurship course is offered to 5th semester's students and at each semester they are invited to develop a product characterised as an innovation. According to Sullivan and Dooley (2008, p.5) "Innovation is the process of making changes to something established by introducing something new that adds value to customers and contributes to the knowledge store of the organization". According to the same author, an innovation differs from an invention once the last one brings something new but that not necessarily fulfil customer needs.

To this challenge the students are guided by the teacher to consider the final product as the project outcome. The students are also invited to present the product's business plan as one of the academic outcomes. According to Schilit (1987, p.13) a business plan "[...] is clearly the result of diligent research and sound financial projections", delineating short and long-term objectives with their correspondent and appropriate guidelines.

At 2015 in the first version of learning approach changing (from traditional to PBL) to the entrepreneurship program, the students were invited to develop a business plan associated with business & sport, more specifically about floor-ball game. The motivation for the floor-ball game PBL came from a previously contact in 2014, made by the teacher together with students from ProAkatemia business administration program in TAMK/Finland (Tampere University of Applied Sciences). In this encounter, the TAMK's students were interested in making contact and exchange business ideas to the Brazilian's students (Integração dos Cursos no Projeto Floorball, 2015). The final result from this experience was a Business Plan. Unfortunately, no further business or academic contact had happened among students from both universities.

The second version of the implementation of a new learning approach to the Entrepreneurship course in the Business Administration (BA) undergraduate program happened in 2016. The new students from BA's fifth semester were challenged to develop a business project concerning a theme from their choice. In a different way from the first version, the students were not driven to choose a project theme. At that moment their choice was a Food Truck business. The food truck was not a social common concept at that time and that the academic experience was more immersive compared to the first version. As results, a food truck business plan was proposed by students and furthermore a team of students have opened a business in a city's mall (Uebe Mansur et al., 2016a).

According to the table below, ten milestones and assessment models were defined.

Table 1. BA_PBL milestones

Aspect	Category		Authorship		Scheduling on Project		
	Summative	Formative	Tutor	Student	Beginning	Middle	End
Business Plan Document	x		x				x
Business prototype	x		x				x
Presentation	x		x				x
Self-Assessment		x	x			x	x
Peer Assessment		x	x			x	x
Teams' project goals	x	x		x	x	x	x

The team's project goals were defined by the students as team checkpoints. These checkpoints had not straight inference in the student's final grade once its proposal were to promote discussion and reflection among the teams members to their self-assessment and peer-assessment steps proposed by the tutor. Examples of these aspects are related to the member accomplish of some team goal also the effectiveness for the team accomplish of some goal or resource previously established and demanded by the project.

4 IEM11_IPIEM1 PBL vs Business Administration PBL

This section presents the IEM11_IPIEM1 vs PBL in Entrepreneurship course of Business Administration program (BA_PBL) implementations comparing the two structures, which is centered in the following topics: number of

ECTS, academic year, objective, duration and courses integrated, competences to apply, number of milestones, assessment instruments used, teams dimension (teachers and students), tutor role and infrastructures.

4.1 PBL models differences

The Table 2 synthetizes main differences between the two PBL models answering to the first question raised up in the research methodology.

Table 2. Characterization of IEM11_IPIEM1 vs BA_PBL

Aspects	IEM11_IPIEM1	BA_PBL
ECTS	5	Not applied
Academic year	1st	5th
Duration	One semester (Sept.-Jan.)	One semester (Jul-Dec)
Project Supporting Courses	5	1
Competences to apply	Technical and transversal (soft)	Technical and personal skills
Milestones	6	10
Assessment instruments	Project team grade (80%) => Presentations (20%), Reports (60%), and Prototypes (20%) Individual grade (20%) => Project written test (20%) + Peer assessment	Summative (50%) Formative (50%) (*) (*) Not including Team's project goals
Students team dimension	7-10	Variable
Teachers coordination team dimension	7-12	1
Tutor role	Monitoring, guiding and reporting to teachers team progress of the teams	Monitoring and guidance according the decisions made by the teams
Infrastructure	Project meeting room	Project meeting room

From this table it is possible to see two very different models of PBL. Main difference that impact the others aspects is the number of PSC in each model that in the case of IEM11_IPIEM1 implies a great effort from the coordinator related to the number of stakeholders involved (e.g. teachers, tutors, students). Nevertheless the objectives are the same: provide technical and transversal competences to the students. The discussion that follows tries to answer to the other questions raised in the research methodology.

4.2 Discussion

This section presents a discussion attending to the teachers experience but also to the students satisfaction surveys results.

In the case of IEM11_IPIEM1, the authors believe that achieved a consolidated model after 14 editions. Nevertheless every year a reflexion occur about the learning process involving all stakeholders in this process. To the teachers interest that students learn in an integrated way the learning outcomes expected for the course of the first semester of IEM11 and this has been the main difficulty felt by the teachers, i.e., how to integrate them in order to achieve students understanding (Alves et al., n.d.). This also demands a close collaboration between teachers that is, probably, the biggest difference from the traditional classes to a project semester. Despite the difficulties being felt, mainly, with the workload (Alves, Sousa, & Lima, 2009) and the need to adjust contents to the project theme (Alves et al., 2016b) implying, many times, practices changing (Alves et al., 2016a), the experience has been positive and satisfied. The teacher abandon his/her role of faculty as an authority and assumes the role of a facilitator and a mentor of the learning process. Sometimes, it seems that the classes are out of control without knowing what the students will present, many times, astonishing positively the teachers.

They go beyond the expected, pulling from the teacher (or others department teachers, researchers, company managers) what they need to achieve successfully the project. PBL is an effective tool to acquire competences and to transform students in Lean thinkers (Alves, Moreira, Leão, & Flumerfelt, 2017).

From the side of the students, surveys are filled every year by them after the end of the project to understand their opinion about IEM11_PIEGI1 PBL. These results are discussed in a workshop that put in front teachers and students discussing what went well and what went wrong in the project. Nevertheless, peer assessment and how to integrate courses contents in the project have been the main difficulties they faced. Because they are freshman students in the first semester, they do not know other model so they do not have the experience of a traditional class's semester. But, when go to the second semester, normally, they compared the semesters and, most students, felt demotivated (Ramires, Martins, Cunha, & Alves, 2016).

In general, students liked the project and recognize their importance (Alves et al., 2012; Fernandes, Mesquita, Flores, & Lima, 2014) because they felt engaged. Also, along the years it is impressive their engagement in extracurricular activities such as their activity in alumni associations that show a dynamism towards to increase their collaboration on the international association of Industrial Engineers students (ESTIEM). Their activity is so intense that they were invited to become the magazine editors, while the number of participants in the international events was never so high. This could be seen as a social competence achieved through the PBL. Furthermore, some were even interested in starting their new experience in publishing papers (Ramires, Martins, Cunha, & Alves, 2016) or in publishing their master dissertation final results in conferences and journals. A list of these publications can be seen in (Alves, Sousa, Dinis-Carvalho, & Moreira, 2017).

The Business Administration PBL is a recent implementation once it is going to its third version. The model is in consolidation process and some results related to the implementation process (Uebe Mansur et al., 2016a) and students' assessment (Uebe Mansur et al., 2016b) seems to bring positive and satisfying feedback.

The most difficult related to the PBL development consists in a break of student's traditional way of thought. They originally have driven their thoughts and way of learning in a Cartesian and fragmented process since it is the regular learning approach they usually get in touch from beginning of their academic life. In this context the teacher assumes a teacher-centred learning approach defining what, when, where and how the students need to learn. From this context, the students got shocked and lost when they are empowered by the teacher in the BA PBL and figure out themselves as the owner of their learning process.

All the rules related to the learning process are explained in the first team meetings. The students take notice that they need to define the team steps to three academic final products: 1) a final presentation as realistic as possible according to the proposed business; 2) a business plan has taken by the teacher as summative assessment; 3) a set of checkpoints defined by themselves to the teams and defined as formative (self and peer) assessment.

The students got very excited when they noticed that it was in their hands the possibility to define the team checkpoints also the verification of the effectiveness of teams' actions. During the process, they could feel the responsibility to the tasks scheduling and situations related to the low-effectiveness of the team tasks accomplishment. After this first impact, they decided to accomplish team meetings specifically to discuss the team members' engagement.

The second version of PBL experience was a disruptive experience for all teaching and learning stakeholders: students, teacher, BA program and college. It has been possible to the students go beyond the usual and simple result of technical knowledge acquiring. The students got satisfied since they were able to explore their personal skills related to the leadership, conflict manager also time and tasks management. For the teacher, it was a rewarding experience once the learning process was not limited to a chalk-and-talk class where knowledge is usually transmitted as a result of a misunderstanding of the teaching process.

5 Conclusion

PBL learning approach represents an alternative teaching-learning approach in comparison to the traditional discipline-centred approach. This puts a lot of challenges: from the students who need to re-learn about to learn, to the teachers who need to think themselves as guides and not any more as a centre of knowledge. Such challenges are also related with the higher effort of organization and coordination, even, when just one course is involved, new ways of rethinking the assessment in order to push learning responsibility to the students.

In the case of IEM PBL model, and even, after 14 editions the model is under continuous improvements since as a project suffers from the regular projects definition: each project is a unique event. In spite of some rules could become standardized, a lot of aspects are rethink every year to better satisfy the "clients" (students and teachers) demands. For the Business Administration program, the PBL experience represents a challenge once it represents a complex learning environment (Uebe Mansur, 2011) at the same time that provokes a discussion about a re-engineering in the way that the administration themes are offered to the students.

The experiences compared in this paper demonstrates that PBL is also an interesting learning-teaching approach choice independent of country, college program or maturity in its application. Challenges are also present in every situation where new paths are proposed but when stakeholders' engagement is constant, the results can be satisfactory.

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Entrepreneurial and Engineering Education - a twofer proposal

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Abstract
One of the main challenges of entrepreneurship education is to become a cross-curricular teaching practice and not an encapsulated discipline. This article discusses the possibility that technical disciplines assume the role of developing entrepreneurial skills in training engineers. A question guided this study: How can a technical discipline collaborate to develop entrepreneurial skills compared to a discipline of entrepreneurship? A research was conducted with students who participated in two disciplines offered at a Brazilian university to electrical engineering students. Both disciplines adopted applications of project-based learning (PBL). A student survey revealed that both disciplines had similar impacts in terms of the development of entrepreneurial skills. The following outcomes can be highlighted: a) the perception of motivation to perform in an entrepreneurial manner in both disciplines was the same, with 58% of concordance by the students; b) the perception of development of entrepreneurial skills was higher at the technical discipline than at the entrepreneurial one (68% against 49%); c) the perception of effectiveness of the pedagogical approach (PBL) was quite similar (71% at the technical discipline and 67% at the entrepreneurial one) and d) the perception of development of business skills was higher at the entrepreneurial discipline (51% against 11%), because this is a direct content of this discipline and at the technical discipline this content is not taught. This study shows that the entrepreneurial education (EE) is an important part of engineering formation. PBL approach proved its value to engage students and to turn learning into an interesting and experiential journey for the students. It was possible to point out important strategies technical disciplines can use in order to improve the development of entrepreneurial skills, such as: team management, hands-on prototype development, problem-solving environment, leadership training and project based learning itself.

Keywords: Entrepreneurial Education; Engineering Education; Project-Based Learning

1 Introduction

One of the biggest challenges of entrepreneurship education is to involve the entire university. Entrepreneurship education has long left the exclusive purview of the business school. Its relevance to engineering and the sciences has never been clearer. Many engineering programs have embraced entrepreneurship, establishing their own faculties and curriculum (Engel, Schindehutte, Neck, Smilor, & Rossi, 2016 Maresch, Harms, Kailer, & Wimmer-Wurm, 2016). In Brazil, 56% of Engineering Schools offer entrepreneurship courses to their students (Endeavor Brasil, 2017).

The increasing importance of entrepreneurship education to engineers is due to the new social imperatives that made it essential that universities assume a responsible role as trainers of good professionals capable of entering, and thriving in, the workplace (Täks, Tynjälä, Toding, Kukemelk, & Venessar, 2014). This challenge becomes bigger when Schulte (2004) says that the university of our times must create job creators and not job seekers. In engineering fields, university departments should seek to provide students with a broad range of skills and knowledge beyond the merely technical (Ohland, Frillman, Miller, & Carolina, 2004), including good communication skills, expertise in multidisciplinary teamwork, entrepreneurial spirit, global and multilateral approaches to problem-solving, and sensitivity to the cultural, social and economic environment (Torres, Velez Arocho, & Pabon, 1997).

In face of this context, it can be seen that both entrepreneurship education and the adoption of active learning methodologies have had considerable relevance in the context of engineering education. This is due to the fact that both educational applications aim to provide engineers with entrepreneurial and management skills (Papayannakis, Kastelli, Damigos, & Mavrotas, 2008) that will enhance their profiles in accordance to the new requirements of a knowledge-based economy.

In order to address this matter, this article aims to report the EE experience of two is professors from the Itabira campus of Itajubá Federal University, a technological campus with 9 engineering courses. Both professors used project based learning strategies. One discipline is exclusively about entrepreneurship. The other one is a technological discipline. To test the hypothesis that entrepreneurship can be taught in technological disciplines, this paper shows the learning results of these experiences in an engineering context. The model for entrepreneurial education that guided the study was proposed by Pretorius, Nieman, & Vuuren (2005) that asserts that the entrepreneurial education depends on the facilitator's ability and skills to enhance motivation, entrepreneurial skills, and business skills through the creative use of different approaches.

This article contains six parts. This first part is the introduction. The second part is the theoretical framework for understanding the entrepreneurial education in engineering context. The third part presents the research procedures, consisting of questionnaires answered by the students during 2016's first semester. The fourth part discusses the data. The fifth part contains final considerations about this study and, finally, the sixth part lists the bibliographic references used in this work.

2 Entrepreneurial Education in Engineering Context

While business schools host the majority of entrepreneurship programs, engineering schools are realizing that entrepreneurship is a vital area of study and practice for engineers and applied scientists (Endeavor Brasil, 2016; Mcgourty, 2009). Some engineering schools in US offer a full major in entrepreneurship and others offered minors or certificates. Stanford University and Massachusetts Institute of Technology (MIT) are always cited as avant-garde institutions that offer courses, conferences, internships, research activities and even venture programs designed to promote entrepreneurship (Mcgourty, 2009; Endeavor Brasil, 2017).

The growing importance of entrepreneurship in the engineering context can be noticed by the increasing number of publication in this area. Using the Elsevier Scopus search service (https://www.scopus.com/), it was possible to identify, on 15 September 2017, 2,029 documents published in indexed journals, which used the terms ‘engineering’ and ‘entrepreneurship’. The terms were used to search simultaneously in title, abstract and keywords. Using the same criteria and adding the terms ‘engineering’ and ‘entrepreneurship education’ 1202 documents published were found. Although this method could be improved, Figure 1 shows a general perspective on the exponential growing in the interest in entrepreneurship in engineering context.

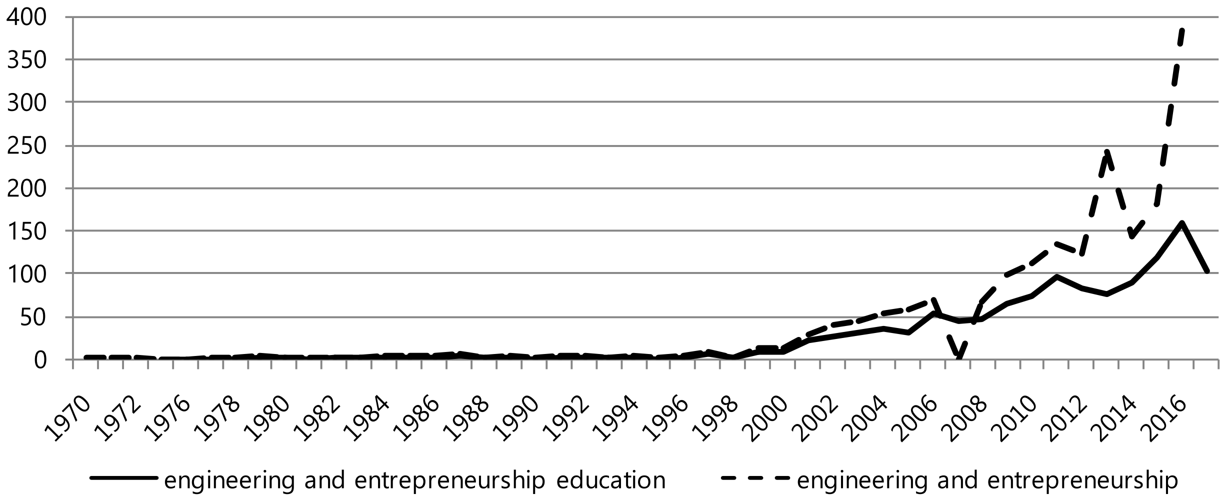

Figure 1. A perspective about the growth of published documents on entrepreneurship on engineering context.

Standish-Kuon T. & Rice, M.P. (2002) found three models of introducing entrepreneurship to engineering and science students. They analysed the programs of 06 American universities and classified then according to the location of the programs (Business school, Engineering School or Multi-school). This shows the possibilities on engineering school have to offer entrepreneurship education to their students. In the same direction, Turner & Gianiodis (2017) identified the growing trend in entrepreneurship education is the development of blended entrepreneurial programs (BEPs)—programs that merge entrepreneurial curriculum with a technical degree—located outside traditional business school settings.

Never than less, many experiences of EE found in the literature are disciplines of entrepreneurship offered by Business Schools or by entrepreneurship professors inside engineering courses. These disciplines varies in the content and stage of business development. Sullivan, Carlson, & Carlson (2001) reported their experience of a invention and innovation course for engineering students. As they said this course cultivated an understanding of the entrepreneurship and invention world through a hands-on introduction to product design and development.

Creed, Suuberg, & Crawford (2002) reported two courses from an engineering department that attempts to provide senior undergraduates an introduction to a technology-based entrepreneurial environment. Its objective is prepare young engineers to new technologies environment which is provided by co-working agenda with companies which present a seed idea that will be developed by students. Attending this course, students deal with real industrial problems and interact with personnel of the company until the solution presentation. According to Creed, Suuberg, & Crawford (2002) these students have a deep experience in developing and validating new technology.

Mendelson (2001) reported an interesting experience that help students come from the ideation of a new business to market commercialization. It comprises three courses (New Product Design & Development, Entrepreneurship and Project/Thesis). All courses operates in multidisciplinary teams of engineering and business students. At the end of the courses, the outputs are evaluated by a product review board that comprises venture capitalists, patent attorneys, presidents of small engineering enterprises, and our faculty. The teams are encouraged to form incubators, which could lead to small businesses.

Gimenez, Bambini, & Bonacelli (2016) discussed the case of State University of Campinas (UNICAMP), one of the most awarded university for its initiatives of innovation and entrepreneurship. Brazilian model. At Unicamp disciplines of entrepreneurship are offered to undergraduate and graduate students, both by the incubator Inova, and by academic units of Unicamp. The aim of this disciplines is to raise awareness of the community entrepreneurship and innovation, and to enable students to use entrepreneurial tools and themes such as Intellectual Property, innovation and entrepreneurship. What makes this model interesting is the incubator becomes an EE space opened to the students.

Noronha, Fowler, & Santanna (2016) shows the case of University of Itajubá. There, eight courses are offered to guide the students from ideation to market commercialization of the business ideas. The students can get a minor degree if students attend at least 5 courses. To get this minor degree, the student must take part at a extension entrepreneurship project and deliver a Disruptive Thesis, which is an start up proposal.

Reinforcing this paper hypothesis that a technological discipline can be used to teach entrepreneurship, Jamison IV (2017) used the Introduction to Biomechanics course focused on developing skills related to opportunity identification and impact evaluation. Changes in the perception of entrepreneurial skills level before and after completing the ideation project were statistically significant ($p < 0.05$). The results indicate that the experience was successful in integrating entrepreneurially minded learning in a senior-level elective and developing an entrepreneurial minded skill set (Jamison IV, 2017).

To extend the results of EE, the literature shows some important challenges. Hashimoto (2013), in his research on entrepreneurship centers, calls attention to the need for a new paradigm in Brazilian EE in which professors would use more extensively the experiential and dynamic approaches, proposing activities that would challenge students with the use of simulations, laboratories, practices, and tests. According to him, training for professors is important for them to assume a new position and acquire a new pedagogical repertoire to improve EE in Brazil (Lima, Lopes, Nassif, & Silva, 2015).

Besides the importance of using a more practical approach to entrepreneurship education, Engel et al, (2016) points other challenges to EE that must be tackle to take EE to a higher level, which are: 1) to increase the offer of higher education programs, courses, and activities in entrepreneurship; 2) to train more professors and teachers in entrepreneurship education; 3) to increase proximity to and contact with entrepreneurs and their reality; and 4) Increase the diversity in course and activity offerings at colleges and universities beyond business planning.

2.1 Project Based Learning

Projects are finite endeavours with defined goals that rise from a problem, a necessity, an opportunity or interest of a person, a group, or an organization (Barbosa & Moura, 2013). When this concept is used as a pedagogical resource, project based learning (PBL) rises as an AL (active learning) strategy that allows a student to learn by applying these ideas and concepts (Krajcik & Blumenfeld, 2006).

The PBL is a form of situational learning based on the constructivist findings where the student gains a profound comprehension when he or she gets involved in their knowledge development (Krajcik & Blumenfeld, 2006). This approach has been gaining ground especially in applied science universities due to the student´s necessity to develop several learning competences for the professional environment. It is a technique that provides multifaceted learning experiences as opposed to the traditional teaching method (Lettenmeier, Autio, & Jänis, 2014). Several studies have proved that PBL is an active learning approach that can be organized in several ways. It is important to mention that PBL have a effective impact in the development of transversal skill and consequently in the professional formation of engineering students (Lima, Mesquita, Rocha, & Rabelo 2017; van Hattum-Janssen & Mesquita, 2011; Lima, Mesquita, Fernandes, Marinho-Araújo, Rabelo 2015; Lima, Mesquita, & Flores 2014).

According to Barbosa & Moura (2013), there are three categories for this approach: (i) Constructive project: it aims to build something new by introducing innovations or proposing a new solution to a problem or situation. It has a function, form, or process in the inventiveness dimension; (ii) Investigative project: research development on a matter or situation by applying a scientific method; and (iii) Didactic (or explanatory) project aimed to explain, to illustrate, and to reveal the scientific principles of functioning of objects, mechanisms, systems, and so on.

To Krajcik & Blumenfeld (2006) , PBL is an overall approach to the design of learning environments. Learning environments that are project-based have the following five key features: 1. They start with a driving question, a problem to be solved; 2. Students explore the driving question by participating in authentic, situated inquiry, which are processes of problem solving that are central to expert performance in the discipline. As students explore the driving question, they learn and apply important ideas in the discipline; 3. Students, teachers, and community members engage in collaborative activities to find solutions to the driving question. This mirrors the complex social situation of expert problem solving; 4. While engaged in the inquiry process, students are exposed to learning technologies that help them participate in activities normally beyond their ability and 5. Students create a set of tangible products that address the driving question. These are shared artefacts, publicly accessible external representations of the class's learning.

Considering all these PBL characteristics, it is possible to conclude that this strategy is broadly used to obtain learning results, including entrepreneurial education (Campos, Pinto, & Campos, 2017). For this to happen, it is believed that the teacher must constantly check whether the students have the appropriate theoretical basis for developing a project. Project activities are widely identified as a valuable component of teaching. The potential for enhancement of competences, peer learning and assessment are considerable together with greater efficiency on staff resources. In this way, it is important that the teacher acts as a tutor by following the intermediary results, and by verifying the progress of the work group. Thus, PBL is presented as an alternative to knowledge development that can be shared internally and externally by the university.

3 Research Procedures

This is a descriptive research (Gonçalves & Meirelles, 2002) that is the most appropriate modality to describe the experiences of EE using the project based learning (PBL) strategy of active learning. In order to know in depth the results of the performed activities, the quantitative strategy was used. According to Gonçalves & Meirelles (2002), this strategy is more adequate for the behaviour quantification and analysis of a given population.

To achieve the objectives of the study, a multiple case study was developed that, as Yin (2005) states, can be useful for testing theories and elucidating situations. The cases studied were the pedagogical experiences of three professors from the Itabira campus of Federal University of Itajubá, who used PBL strategies with the objective to develop entrepreneurial skills in their students.

Data collection was done through the application of a questionnaire that was answered by the students at the end of the courses. The questionnaire was composed of 26 closed questions that students were asked to answer on a 5-point scale that indicated how often the situations in the questions occurred during the disciplines, being 1 for never, 2 for rarely, 3 for some times, 4 for most of the times, and 5 always. These questions were elaborated to evaluate the results of entrepreneurship teaching experiences following the theoretical model proposed by Pretorius et al. (2005). Thus, four sets of questions were raised which were: a) perception of effectiveness of facilitator's ability and skills; b) perception of motivation to perform in an entrepreneurial manner; c) perception of development of entrepreneurial skills and business skills during the taught topic and d) perception of effectiveness of the pedagogical approach (project based learning). For data analysis, descriptive statistics were used to determine the percentage of students that fit into each situation described in the questions.

3.1 Description of the activities developed in the disciplines

3.1.1 Discipline 1 - Scientific, Technological, and Entrepreneurship Introduction (STEI)

This is an authentic entrepreneurial discipline that is part of the curriculum for the electrical engineering and production engineering undergraduate courses. It consists of approximately 60 semester hours (30h theoretical and 30h practical). The main goal of the discipline was to develop business ideas in the students' knowledge area. The project was investigative (Barbosa & Moura, 2013) because the students had to develop and present an executive summary of the business idea formulated by their group.

The discipline was designed to inspire students to develop a business ideia from the ideation phase up to the presentation of a pitch to a review board, composed by the instructor and local entrepreneurs. The content of the discipline was divided in 6 units: Ideation, Business Model, Marketing, Sales, Operation, Financial Planning and Funding. At each class the teacher started with a brief explanation about a specific topic and assigned tasks to the group according each stage of development of the ideia. So in every class, the instructor worked with the groups as a mentor.

The project corresponded to 70% of the final grade, divided in 3 presentation: 1) The chosen problem and the Solution, 3) Business Model and 4) Final Pitch. At this project, prototypes were not compulsory. The other assessment activities were in class discussion (20%) and to deliver a text about start up cases (10%).

3.1.2 Discipline 2 - Industrial Instrumentation (II)

This technical discipline is part of the curriculum for the electrical engineering and for control and automation engineering courses. These course consist of approximately 90 semester hours (64h theoretical and 32h practical), with one third of the classes in the instrumentation laboratory. In this discipline, a project was proposed with the main goal to solve a real problem by assembling sensors and conditioning their signals.

Thereafter, the students were supposed to develop an electrical signal conditioning system that is in the range of 0 to 5 Volts, as it is used in the industry, being compulsory the use of some type of sensor. The prototype of the project had to be delivered on a prototyped electronic board, and signal conditioning had to be performed using operational amplifiers.

The students were divided into groups of 5 people. Each group was managed by a leader, as if they were in a company, with operational rules, roles, and functions. At the end of the course, each group had to present a prototype as if they were presenting a commercial product to a review board composed by professors and industry members.

The project corresponded to 25% of the final grade. The other assessment activities were tests (45%), exercises (20%), group seminars they had to present about a content topic (10%). The project was assessed considering the following aspects: (i) cooperation with peers (assessed by four peer assessment moments during the semester, (ii) functional prototype, (iii) final paper, and (iv) project presentation. The distribution of the 25 credits assigned to the project is shown in Table 1.

Table 1. Distribution of the 25 credits assigned to the project

Aspects assessed in the project	Percentage of project credits
Peer assessment	10%
Functional prototype	40%
Final paper	20%
Presentation	20%
TOTAL	**100% ≡ 25 credits**

3.2 Presentation of Collected Data

As the authors pointed out on the previous session, the students were asked to answer the questions on a 5-point scale that indicated how often the situations in the questions occurred during the disciplines, being 1 for never, 2 for rarely, 3 for some times, 4 for most of the times, and 5 always. Considering the most frequent situations (responses 4 and 5), the authors got the results presented on Tables 2, 3, 4, and 5 which are considered the assessment level of the constructs indicated on the Pretorius et al. (2005) model.

Table 2 presents the construct motivation to act in an entrepreneurial way. In general, in both disciplines the majority of the students reported they felt more motivated to change their attitudes to solve problems, to contribute to economic development and to turn their ideas into reality. The lower degree of motivation was obtained to manage, and to open a company. It is believed that this data reflects the risk aversion that some students have. This risk aversion has been reported in some studies about the disposition to entrepreneurship (Inacio, 2014). Never then less, it can be said that both discipline obtained the same effectiveness in motivation students to perform in an entrepreneurial manner.

Table 2. Perception of motivation to perform in an entrepreneurial manner

Situation	STEI	II
I felt motivated to adopt new attitudes to solve problems.	69%	71%
I felt motivated to contribute to economic development through new technologies.	67%	64%
I felt motivated to turn my ideas into reality.	54%	71%
I felt motivated to be a manager in a company.	52%	50%
I felt motivated to start a business.	50%	36%

Mean of each discipline	58%	58%

Table 3 presents the construct development of entrepreneurial skills. During the development of the disciplines, the majority of students report that they improved their persistence, creativity, critical thinking, planning, and project management. It was noticed in a smaller proportion that the abilities to identify an opportunity, leadership, confrontation of risky situations, and innovation were less developed. Even though, the students reported difficulties to create innovations based on their own knowledge. It is important to noticed that the technological discipline II was more effective to develop entrepreneurial skills than the entrepreneurial discipline STEI. According to the data every entrepreneurial skill was more encouraged in the technical discipline.

Table 3: Perception of development of entrepreneurial skills during the taught topic

Situation	STEI	II
I developed my persistence to achieve goals.	57%	86%
I developed my ability to think creatively and critically.	61%	71%
I have developed my ability to plan and manage projects to achieve objectives.	61%	71%
I developed my ability to identify opportunities to generate new solutions to real problems.	52%	71%
I developed my leadership ability.	45%	71%
I developed my ability to deal with risky situations.	33%	71%
I developed innovative ideas.	37%	36%
Mean of each discipline	**49%**	**68%**

Business skill development was the construct that obtained the worst evaluation, it is noticed that it has room for improvement for the practices analysed in this article. The indexes were considered low when students were asked whether they had learned management techniques during the deployment of the discipline. The perception of development of business skills was higher at the entrepreneurial discipline with the mean of 51% against the mean of 11% in the technical discipline. The contents related to business skills is taught only in the entrepreneurial discipline STEI, even though it can be noticed that the learning results of these topics were low. These are very relevant techniques for entrepreneurial activity, which demonstrates a need for improvement in future practices.

Table 4: Perception of development of business skills during the discipline

Situation	STEI	II
I have known business financial management techniques.	61%	14%
I have known marketing / business communication management techniques.	57%	14%
I have known business operational resource management techniques.	56%	0%
I have known people management techniques.	50%	14%
I have known business legal implications.	30%	14%
Mean of each discipline	**51%**	**68%**

With regard to the construct pedagogical approach, it is considered that the experience was well evaluated in both disciplines. According to the students, the teacher / student relationship and the student / student relationship were facilitated. This allowed the students to report that they had learned how to work in groups. Regarding the essential purpose of AL strategies, which enables the student to be permanently active in the learning process, it was reported that 69% of the students felt responsible for their learning (in both disciplines). In general, the perception of effectiveness of the pedagogical approach (project based learning) in the technical discipline was higher than in the entrepreneurial discipline STEI.

Table 5: Perception of effectiveness of the pedagogical approach (project based learning).

Situation	STEI	II
The teacher / student relationship was facilitated.	83%	57%
The student / student relationship was facilitated.	76%	79%
I learned to work in a group.	74%	79%
I felt like an active agent in your learning process.	69%	79%
I felt responsible for my own learning.	63%	93%
The learning was acquired when dealing with actual problems.	61%	50%
I developed skills that would not be developed by another method	46%	57%
Mean of each discipline	**65%**	**73%**

4 Data Discussion

This is the question that guided the study: How can a technical discipline collaborate to develop entrepreneurial skills compared to a discipline of entrepreneurship?

Due to the importance of entrepreneurial education to engineering context added to the difficulty some Engineering schools have to offer this extra content it can be considered that a technical discipline can be as effective as an entrepreneurial discipline to promote the development of entrepreneurial skills. So that, it would be useful expand the learning results of the engineering technical formation in order to develop important transversal skills considered entrepreneurial skill. It must be emphasised that the hands-on activities to develop a prototype, in the Instrumentation Laboratory, in the technical discipline II played an important role to help students to develop their entrepreneurial skills.

As it was demonstrated in the previews session, both discipline had similar effectiveness to motivate students to perform in an entrepreneurial manner. The motivation to manage or to start a new business generated by the disciplines can be considered low because it does not represent the majority of the students analyzed (50% for STEI and 36% for II). Never then less, this percentage is similar to Brazilian students percentage of potential entrepreneurs identified by Endeavor Brasil (2017) which is 21% of the students.

In general, the application of the active learning strategy PBL had positive impacts on students' learning, who experienced the development of projects that generated solutions to real problems. It is important to emphasise that technical disciplines will be able to impact the entrepreneurial behaviour of student if they are based in active learning strategies such PBL. As advocated by Pretorius et al., (2005) the facilitator plays an important role, and it can be concluded that the facilitator's performance was decisive to motivate and transmit knowledge in the experiences reported. It must be stressed that the facilitator/instructor is important because he or she will choose the strategy and will lead student through the learning process. The learning process is not centred on him or her like in a traditional way of teaching (Prince, 2004) but is intentionally guided by the facilitator/instructor. The assessment procedure used in the technical discipline was important engage students to collaborate with each other. It was decisive to develop the team working skills and leadership.

Regarding the questions that reflect the perception of development of business skills during the program, important considerations on the opportunities for improvement can be made in the entrepreneurial discipline. It is believed that it is imperative that during the programme students are invited to reflect on the mindset that governs their behaviour (Sidhu, Singer, Johnsson, & Suoranta, 2015). One of the highlights was the issue related to the development of business skills, with particular emphasis on the legal implications of business. At this point, it is understood that it will be necessary to reformulate the way the information is shared, making use of actions of partnerships with specialized professionals. These findings highlighted the importance of building a solid support network involving a whole range of aspects and roles, and carrying out continuous monitoring.

Never then less, it can be concluded that in the case of technical disciplines it is very difficult to address this issue due to the specifics contents this discipline must cover.

The last group of questions focused on the perception of effectiveness of the pedagogical approach (PBL). The mean of the responses was 65% to STEI and 73% to II, which shows that the students realized how different the application of the adopted pedagogical technique was and how they benefited from it by learning in a different way. This different form of learning involves improving the relationship between the students and the teacher, between the students themselves, and also through the sharing of responsibility in their learning. Students understood that the teacher can facilitate the learning process, but they need to take an active role in developing the activities.

Data showed that those pedagogical experiences were good enough to generate an attitudinal and behavioural modification by the participant after having attended the programme no matter it was exclusively about entrepreneurship or about a technical issue. The authors also noticed, by this research, that this modified attitude will lead to activities associated with business start-ups or entrepreneurship on established enterprises in the future. The survey indicated that the facilitators impacted the participant in such a way that the attitude and behaviour were modified. Nevertheless, the outcomes of start-up creation can only be measured in the future.

5 Final Consideration

It can be said that a technical discipline can develop entrepreneurial skills and can motivate students to perform in an entrepreneurial manner if they are based in active learning strategies such as PBL. PBL is one of the methodologies that help students and teachers build learning environments. With all of PBL´s characteristics, it is possible to development strategies to obtain learning results: students learn and apply important ideas, development collaborative activities to find solutions to the driving question, students can learn with technologies and create a set of tangible products. Compared to an entrepreneurial discipline, a technical one is not effective to teach business skills related to marketing, operations, finance and legal implication. But it is not the purpose of this argument once a technical discipline has its own contents to cover. In reality, engineer students can access this knowledge in other disciplines which content is related to business. Yet, It was noted that the motivation could be greater if the formation and pulverization of the entrepreneurial culture was deployed throughout the course, and not only in some disciplines in different semester. It is understood that teachers should constantly seek the updating of techniques and mechanisms to improve the sharing of knowledge with students. Another important aspect to be considered in future experiments is the assessment of knowledge and skills before and after the disciplines. This procedure would allow for more accurate comparisons of the behavioural changes that the program generated. As possibilities for future studies, the authors aim to analyze the impact of extra-class activities in the development of entrepreneurial skills and yet compare practices of other technical disciplines. This study showed that the entrepreneurial education in the engineering context can improve. For this reason, entrepreneurship cannot be encapsulate in one discipline. In doing so, technical disciplines can do the job in a twofer proposal. It is possible to "kill two birds with a stone". In a technical discipline it is possible to teach technical knowledge and help students to develop their entrepreneurial mindset. PBL approach can be effective in this purpose engaging students in an interesting journey. This research pointed out opportunities for improvement in the practice of involved facilitator, such as the integration of technological and entrepreneurial disciplines, the involvement of external mentors and professionals, and a solid behaviour orientation toward an entrepreneurial mindset.

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The adoption of business simulation as a pedagogical alternative within a problem-based learning approach (PBL) in engineering education.

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Abstract

The teaching of engineering today is no different from how it was in the past. It consists of the mediated exposure of content, where the teacher transmits knowledge and guides student activities. Problem-Based Learning (PBL) emerges as a methodological alternative, in which students solve a real or simulated problem in a context. It is a student-centered method, where students assume the protagonist's role in their learning. What if it were possible to integrate decision-making training using business games into PBL?

The purpose of this article is to study the use of business games, within a PBL approach, in which the student will gather and analyze information in an integrated decision-making process. To conduct this research the Consultation-Interview methodology will be used, in which a set of experts will be selected to be interviewed on a topic. For the first interviewee, the procedure consists of preparing a questionnaire appropriate to the individual. These questions will guide the interview with this specialist. After the first interview a synthesis will be drawn, which will guide the preparation of the questionnaire for the second interviewee. In the second interview, information obtained in the first interview will be corroborated and the new knowledge will be aggregated to the old. This process will be repeated until no new knowledge can be gleaned from the interviews. This methodology was developed by Professor Feruccio Bilich in the report "Rethinking UnB Undergraduate Education" in 1987 and later published in the book *Science and Technology Planning and Policy* (Elsevier, Amsterdam). It is hoped that the present study will lead to new methodologies to enable students to develop the decision-making skills fundamental for engineering professionals. At the end of the study, we expect to develop a methodology that integrates business games into a PBL environment and contributes to the improvement of teaching/learning processes.

Keywords: Problem-Based Learning; business games; decision-making

1 Introduction

Despite the transformations the world has undergone in recent decades, in terms of technological progress one environment has remained to a certain degree cutoff from these changes: the classroom. In engineering schools, particularly in the field of production engineering, classes are taught little differently from how they were taught decades ago. Chalk and blackboards have given way to PowerPoint and projector screens, but classes remain centered on the teacher figure, holding and transmitting knowledge.

The information society has put this form of teaching in check by providing opportunities for significant changes in the teaching-learning process.

We have seen attempts to implement changes in recent years most of all in higher education, in spite of resistance from conservative groups in the academic world that perceive the traditional classroom dynamic, where knowledge is the sole focus, as their comfort zone.

If competence comes from the combination of knowledge, skills and attitudes in the classroom, then considering only the dissemination of knowledge — as in the traditional approach — does not contribute to the preparation for the challenges of the modern world. Beyond knowledge, it is necessary to develop abilities and attitudes in the students. PBL, problem-based or project-based learning, which we shall discuss later, is a participatory teaching-learning methodology, in which problem situations stimulate the learning of concepts and theories for skills and other development in the classroom.

Nonetheless, a gap remains in the training of the production engineering professional — specifically, in the development of student attitudes for the analysis of information in the environment, the market and organizations in an integrated way, and the subsequent making of appropriate decisions.

The present study aims to analyze the role of business simulation / business games as a methodological alternative for classrooms and laboratories, in order to develop in production engineering students the attitude to analyze information and make decisions that will affect results.

This study will analyze the application of business simulation as a didactic-pedagogical resource that facilitates teaching and learning to fill the above-mentioned gap in the training of production engineers, i.e. the development of what I am calling "attitude," which is the disposition and readiness, the initiative, to make decisions, to act.

The study will also analyze challenges to the adoption of the business simulation methodology in an undergraduate course in production engineering, its acceptance, premises, and results in the teaching-learning process and in the training of professionals.

2 The teaching-learning process: learning models

2.1 The knowledge-skills-attitude approach

The goal of any university is to develop / train competent professionals. But what is competence?

Competence is commonly used to designate a person qualified to develop an activity. Its antonym does not only imply the negation of this capacity, but it has a pejorative meaning in modern language, indicating that a professional has been or presently will be sidelined within the labor market and, consequently, lose prestige and social recognition.

(Webster's Dictionary 1981: 63) defines competence as: "the quality or state of being functionally adequate or having sufficient knowledge, judgment, skills, or strength for a given task." This definition names three main points related to competence — knowledge, skills and judgment. Judgment refers to the ability to decide.

The Portuguese-language dictionary *Aurélio* emphasizes similar aspects: a capacity to solve problems, aptitude, suitability, and introduces another: the legal capacity to judge cases. That is, to make a decision.

In recent years, the subject of competence has been incorporated into academic and professional discussions, related to different perspectives on understanding: at the level of the individual (the competence of the person), of companies (core competencies), and of countries (educational systems and skills training).

(Le Boterf 1995) presents a competence structure reinforced by (Fleury 2002). The fundamental components of this structure are knowledge, will, and the power to act.

(Woodruffe 1991) classifies competencies in fundaments (knowledge and skills) and differentials (attitudes) and stresses the importance of considering too the skills difficult to acquire, so that they can be perfected. According to him, the more difficult the acquisition of a competence, the less flexible we should be at the time of hiring.

In the perspective adopted here, competence is not limited to a stock of theoretical and empirical knowledge held by the individual, nor is it encapsulated in the activity. According to (Zarifian 1999), competence is the practical intelligence for situations that depend on acquired knowledge and transform it with a force that increases with said situations' complexity.

Based on the fact that competence is not limited to accumulating determined knowledge, a new acronym emerged associated with competence and its main aspects — knowledge, skill and attitude (KSA or ASK).

Knowledge is theoretical. Knowledge is usually tacit, present only in the professional's mind. The great challenge of organizations is to transform tacit knowledge into explicit knowledge and into an organization's intellectual property and heritage. It must be incorporated into the organization, made available to all, democratized throughout the enterprise. Know-how must be known by everyone, as this is vital to an organization's survival. There has been increasing discussion of mapping and managing competencies in organizations.

Skills are practical. Ideally, we combine knowledge and skills, but this can be more difficult than it at first appears. Many people still find it difficult to join theory to practice. To counter this stereotype, the tendency is to talk of theory and applied theory. Often those with the knowledge are not the ones executing. Skills, as a rule, depend on practice, training, and trial and error. Practice, or the application of theory, "makes perfect," as the saying goes. It is necessary to bring the planning team closer to the team that executes. How to do that is the question. This is seen as a serious organizational problem, and very little has been done by the academy to correct, or at least attenuate, the problem.

Finally, attitude is linked to action. It is no use having knowledge and skill and no attitude. Attitude is having the will and confidence to make decisions and implement them. Many professionals are unwilling to change. They realize that if certain things change, things will improve. But why change what works? Attitude for change, the will-to-change, is essential for change to take place. Attitude is essential for results in companies.

2.2 Problem-based learning

The depletion of the conventional model of higher education led to the emergence of a new approach, called PBL, or Problem-Based Learning, originally conceived for the teaching of medicine at McMaster University.

According to (Ribeiro 2010):

PBL is a collaborative, constructivist and contextualized teaching-learning methodology, in which problem situations are used to initiate, direct and motivate the learning of concepts, theories, and skill and attitude development in the context of the classroom, without the need to design courses specifically for this purpose.

Problem-Based Learning is, therefore, a model that organizes learning based on projects. According to the definitions found in the literature, *projects* are complex tasks, involving challenging questions or problems, in which students design and solve problems, make decisions, or conduct research activities that offer them the opportunity to work relatively independently for long periods of time that culminate in results (Jones, Rasmussen, & Moffitt, 1997; Thomas, Mergendoller, Michaelson, 1999).

According to (Thomas 2000), other PBL components are "authentic content, authentic assessment, teacher facilitation, but not direction, explicit educational goals, cooperative learning, reflection, and the incorporation of adult skills." He also reports that diverse definitions relate to "the use of an authentic question, a research community, and the use of cognitive (technology-based) tools."

PBL places value on not only the knowledge to be learned, but also the way the learning process occurs, emphasizing students' active role in this process, enabling them to learn how to learn.

It seems evident that PBL stimulates the development of technical, cognitive, and communication skills; respect for student autonomy; teamwork; and lifelong education. However, it is limited when it comes to developing attitudinal skills in the student.

This view is partially corroborated when PBL's limitations are addressed.

Time is cited as one of the bottlenecks, since it is difficult to develop the construction of knowledge quickly, as is done in traditional methods. With PBL, more time is required for students to achieve a satisfactory level of learning. The difficulty arises because, in making students active and autonomous in their learning process, the length of the course must be extended, in order to obtain the desired results; otherwise, students may feel insecure about their mastery of the information (Margetson, 1997; Barell, 2007; Delisle, 2000; Carvalho, 2009). An insecure professional will not have the attitude necessary to become a competent professional.

2.3 Business simulation as a didactic-pedagogical resource in learning

Teaching in Brazil and throughout the world, as discussed above, is still strongly based on a system inherited from pedagogy, which puts training in a dilemma, due to the incompatibility of the traditional system with the profound transformations in the business world.

To prepare professionals for a dynamic world and the business environment, higher education institutions need to adapt their pedagogical projects to current reality, seeking new teaching methodologies that can reconcile theory and the application of theory, or practice, giving students a complete vision of their profession and the challenges inherent in it.

In this context, business simulation, or business games, constitutes an alternative, since it takes into account the various schools of thought and theories of teaching, while also appreciating the dynamic aspects of contemporary society, the environment, and the market. This teaching methodology can facilitate the teaching-learning process through simulated practice, giving greater experiential knowledge to professionals in training.

Business simulation, as a course, includes new teaching methods and the use of new information and communication technologies. According to its objectives, during an exercise students identify information needs from virtual companies, carry out investigations in teams under the guidance of a teacher, and decide on and implement solutions appropriate to the development of a particular business activity.

The concepts and characteristics of simulation studies are addressed from the perspective of several experts in the field, e.g. Barcante (2003), Beppu (2007), Gramigna (2007), Lopes (2001), and Santos (2003). They have demonstrated in their research the many benefits of business games / business simulation, for higher education.

According to (Lopes 2001), “the new graduate in Administration is not prepared to face the labor market with the necessary confidence to perform the functions assigned by law to his profession.” He adds that, in order that professionals be trained with the necessary skills to occupy managerial positions or feel confident enough to venture into business, a management course must be formulated on new pedagogical bases, with an adequate theoretical-practical program and the indispensable commitment of the training institution. Business simulation is an excellent complement to traditional techniques of teaching and transmission of knowledge and, focusing on the development of the desired attitude in business managers, should be used in management training programs and formal undergraduate and postgraduate courses (Barçante and Pinto, 2003).

According (Sterman 2000), however, points out the risk that learning programs using “business games” as didactic tools in the learning of the “players” have no impact, since in many cases students make decisions guided by the sole objective of winning the games, without questioning their decisions or understanding more deeply the way they think about the reality in which they are acting. This problem owes to the fact that the simulation model is presented as a so-called “black box,” in which the problem is given and the only way of interacting is by way of specific decisions, with no possibility of further learning.

Problem-based learning (PBL) as an educational method to foster self-directed learning, integration disciplines, small-group learning and decision-making strategies like a business simulation. Both approach are student centred. During the discussion of a business simulation case there are a number of important issues to be considered by students, such as keeping ground rules, knowing their roles, keeping group dynamics, becoming a purposeful learner, planning how to use tutors’ feedback to enhance group discussion and boost student's learning skills, as well as striving to become a winning team.

3 The applied simulation in undergraduate production engineering classes

The simulation software used in the study was Simulação Empresarial de Pequenas Empresas from Tino Empresarial, designed to simulate small companies in the industrial sector. In this sector, companies produce and sell durable consumer goods. The industrial simulator reproduces the operating conditions of the main functional areas of an industry, such as production management, financial management, sales, and human resources.

Before starting the application of the simulation two teachers and two monitors underwent training for 30 days in the application of the software, to play the role of coordinator in the class.

To conduct the Business Simulation the Production Systems Planning class, that adopt PBL metodology, was divided into eight teams, each team responsible for a company. All companies manufactured the same product:

aluminum beverage cans. Despite the software developer's recommendation that each company-team have a maximum of four students, we divided the 55 students into seven teams of seven and one team of six, due to the large class size. Team members were assigned to the functional areas of each company: commercial, production, financial, and human resources, and in the following positions: administrative-financial director, industrial director, commercial manager, human resources manager, production manager, financial manager and marketing analyst .

Before beginning the simulation, the teachers briefed the students on the product to be manufactured, its features, the characteristics of each company, functional areas, positions, as well as the variables to be taken into account within each decision during the simulation. The simulation was conducted by the teachers, acting as simulation coordinators.

At this point, business reports and a newspaper with information on the economy, edited by the simulation coordinators, were distributed to each one of the participants. Each student also received the following: an accounting report with confidential information regarding cash flow, loan limit for the next period, economic results (product cost and annual revenue), and the balance sheet for the simulated period; an operating report with confidential information regarding inventory, machinery, human resources, market data, the economic situation, and decisions made by the company for the simulated period; the newspaper *A Gazeta,* with suppliers' prices for the period, the federal borrowing rate, suppliers' interest rates, product import estimates, P/L percentages on the sale of used machinery, other miscellaneous information needed for decision-making, and select news from the immediately preceding period.

Each company manufactured and marketed the one consumer good mentioned only.

Commercial management was responsible for making decisions regarding buyers, demand, sales price, sales deadline, advertising, seasonality, macro sector growth, import of products, and merchandising. Production management was responsible for decisions regarding production scheduling, types of machinery, purchase and sale of machinery, procurement of raw materials, the expenditure system, and storage and depreciation expenses. Human resource management was involved in decisions regarding hiring, firing, compensation, training, and productivity. Financial management was responsible for decisions regarding loans, financing, anticipation of receivables, investments of cash surpluses in the financial markets, income taxes and arrears and their repercussions on the cash flow of the respective companies.

Decisions were based on 16 variables: the price to be charged for the product and payment arrangements (upfront payment or installments), company investment in marketing and advertising, purchase of raw materials and payment arrangements, increased production, purchase and sale of three types of machines, number of employees hired and dismissed, employee salaries, investment in training, loans requested, anticipation of receivables, investments in the financial markets, and term interest.

Over multiple cycles the companies' performance could be monitored against the following indicators: indebtedness, net working capital, profit margin, market share, net worth, and asset profitability. The classification of companies was based on the performance of the shareholder equity indicator.

Conceptually speaking, shareholder equity is the representation of the effective wealth of a company. In this indicator, information such as the amount invested in the business, the profits that were generated and are awaiting distribution among owners or shareholders, treasury stock, and inventories are collected.

Shareholder equity is calculated through the accounting entries originating in the company's operation. Each input of funds into the business, for example, results in an increase in capital stock, which contributes to shareholder equity. Shareholder equity can be calculated by subtracting liabilities payable from total assets.

The simulation took place over four cycles, after which the companies' performance in terms of shareholder equity was compared.

4 Conclusion

The present study was developed with the aim of understanding the role of business simulation / business games in the teaching-learning process, as a complement to PBL, and of developing attitude, an area little explored in PBL, by production engineering students within the acquisition of competence.

Based on this pilot experience of using business simulation as a complementary activity within the undergraduate course "PSP 7: Production Systems Planning 7" in University of Brasília's Production Engineering program, it is possible to establish preliminary interest and motivation on the part of students.

Placed in the role of company executives, students were exposed to diverse market information and required to make resource-allocation decisions based on this information.

Based on the decisions that were taken during each cycle of the simulation, they observed their respective companies increasing or reducing shareholder equity, which was the indicator used to classify the companies. Analysis of the decisions made vis-à-vis the results achieved allowed the students, at each new stage, to review previous decisions, discussing the information and decisions made with the other "members of the board of directors" of their companies.

It was evident from the follow-up of the simulation that students were required to analyze a large quantity of information shared with other team members, to take positions, to debate, and, finally, to make decisions, implement them, and, naturally, assume the risks inherent in each decision.

If attitude is considered related to action and involves the confidence to act, to make decisions, and to implement them, then the experiment evidenced the important role of simulation in the development of the third component of KSA — attitude.

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Project-Based Learning (PBL) Applied to Developing a Production Systems Project in conjunction with Factory Design and Layout (FDL) Methodology

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Abstract

One of the most complex problems for organizations is the design of configurations for their production systems. In these activities, planning and decision-making are broad in scope, involving corporate policies, and, therefore, long horizons and high degrees of risk and uncertainty. While it is widely accepted that undergraduate-level courses in production engineering need to be aligned with market demands, an absence of integration between market and classroom has been observed, due to the gap between industrial reality and the curricula taught in the vast majority of Brazilian higher educational institutions. The objective of this article is to present the methodology used in Project Based Learning (PBL), developed for production engineering students at the University of Brasília. Utilizing the PBL approach, a Production Systems Project (PSP) was developed, applying Factory Design and Layout (FDL) methodology. At the conclusion of the project, the teams executed the "Production Systems Project" and evaluated the design and the learning process created. The joint use of these methodologies involves both long-term objectives and policies and serves as a guide for all structural decisions in this sector. It can be used as a differentiator in the training of our graduating students and increase companies' competitiveness.

Keywords: Engineering Education; Project Based Learning (PBL), Factory Design and Layout (FDL) methodology.

1 Introduction

Over the past few decades, the competitive intensification among the companies has become a qualifying factor of the levels of customers and consumers requirements and needs. According to research by Guan et al (2006), researchers and managers have been searching for appropriate methods to explore the relationship between technological innovation capability and competitiveness in recent years. In a recent survey covering 182 industrial innovative firms in China, the research results show that only 16% of the enterprises operate on the best-practice frontier and there are some inconsistencies between organizational innovation capability and competitiveness in many enterprises. Research also results further indicate that there is still much room for enterprises to improve competitiveness in situations of confining score ranges of technological innovation capability and competitiveness.

Melo, Fucidjie and Possas (2015) published an article that addresses issues related to the competitiveness of Brazilian industries, in which the paper deals with a central dimension of industrial policies in modern globalized economies, namely innovation policy. From an evolutionary approach, it points out the relationship between technology gaps and competitiveness. The proposed orientation of industrial policy however should go beyond support and (financial and human) resource supply measures, and to inquire the determinants of low innovation efforts by the Brazilian firms.

According to Neuman (2013), it was found out that even when the market was stimulated, most of our companies could not grow sustainably and consolidate positions. Brazilian industry is losing its competitiveness in the domestic and foreign market, the imports of manufactured goods are increasing rapidly and the country runs the risk of a strong deindustrialization, because of the replacement of domestic production for imported products.

According to World Economic Forum (2017), in the ranking that evaluates the competitiveness of 137 countries, Brazil has gone up a place in the ranking of competitiveness prepared for the biennium 2017-2018 after 4 consecutive years of decline, rising from 81^{st} to 80^{th} in the classification. In Latin America, Brazil only performs better than Guatemala, Argentina, Ecuador, Paraguay and Venezuela.

Old beliefs in markets with low competitiveness and high profit margins can no longer be applied. Nowadays all companies must be prepared for the escalation of customer disputes and the sooner they realize that the only way to survive is through the sustained improvement of their performance indicators the better. In this context, companies have to design their production systems and/or operations for continuous improvement of productivity, creating flexible sustainable systems with quickness in the project and development of new products, as well as lead-time and reduced inventories attending to customer needs.

Pachane and Pereira (2004) states that in a brief retrospective of the history of universities - in a general way, and more specifically of Brazilian ones -, it is possible to observe that the required formation of the university professor has been restricted to deep knowledge of the discipline to be taught, may this knowledge be practical (resulting from the professional practice) or theoretical/epistemological (resulting from the academic exercise). Little or nothing has been demanded in pedagogical terms.

Solution to increase the performance indicators of Brazilian companies begins with structural changes in the teaching methodologies and training of higher education professionals. According to Lima et al (2014), training engineering students has been evolving towards the development of professional competences, both technical and transversal. These competences will enable new engineers to apply learning resources in professional contexts with greater efficacy. Thus, these engineers will be closer to the needs of industry.

While the modern world is entering Fourth Industrial Revolution Era, the formation of the engineer cannot be dissociated from the system in which it is inserted. Mills and Treagust (2003) already pointed out that the modern engineering profession deals constantly with uncertainty, with incomplete data and competing (often conflicting) demands from clients, governments, environmental groups and the general public. It requires skills in human relations as well as technical competence. Whilst trying to incorporate more "human" skills into their knowledge base and professional practice, today's engineers must also cope with continual technological and organizational change in the workplace. In addition, they must cope with the commercial realities of industrial practice in the modern world, as well as the legal consequences of every professional decision they make.

In this sense some initiatives are being carried out, such as the case reported by Villas-Boas (2004), in which University of Caxias do Sul (UCS) elaborated the cooperative project called 'The engineer of the future', with the objective of promoting science and engineering among high school teachers and students. The activities of this project were planned to give meaning and foundation to the teaching–learning process of science and for the application of theory in the solution of real problems, while articulating scientific, economic, environmental, social and political aspects and to reinforce the important role of engineering in society. Activities with the engineering instructors of UCS are also being developed in order to help them to incorporate in their classes more effective pedagogical strategies for educating the engineer-to-be.

According to Barrows & Tamblyn (1980), Project-Based Learning (PBL) can be defined as the learning resulting from the process in which students investigate, understand, and solve problems. According to Gilkison (2004), PBL methodology emerged from Canada and it spread to other countries. Bell (2010) reports that it is an innovative approach to learning that teaches a multitude of strategies critical for success in the twenty-first century. Students drive their own learning through inquiry, as well as work collaboratively to research and create projects that reflect their knowledge. From gleaning new, viable technology skills, to becoming proficient communicators and advanced problem solvers, students benefit from this approach to instruction.

2 Scope

According to Balthazar and Mello (2010), curricular proposal of Production Engineering Course at University of Brasília (UnB) was structured in order to enable the engineer to deal with engineering problems within the systemic approach, in which the engineering activity is seen as an interaction of the professional with the various environments in the which its performance interferes and, at the same time, is affected by. In this context, Production Systems Project (PSP) disciplines have focused on the project activity. Each project, assigned as a task to a "project group" that will explore the relevant issues and elaborate answers and solutions throughout the semester, will be structured as follows: (i) A problem; (ii) A context; (iii) Access to resources and information.

Once consolidated as one of the main engineering areas in Brazilian market, Production Engineering is an engineering in harmony with the demands of society. Due to their diversified training, Production Engineers are professionals who are firmly committed to the sustainability of economic, social and environmental development, through the rational use of productive resources with a systemic vision, being able to contribute to regional development and the improvement of quality of life.

For Production Engineers the improvement of the productive processes represents traditionally one of the most peculiar problems to their professional activity and mastering the contents related to the area of Factory Design and Layout, which consists of the design of a system, they will have an opportunity to demonstrate to the market the range and importance of their professional training.

Only between the period from 1950 to 1985 the main studies that resulted in the classic methodologies normally used as reference for the layout design emerged, highlighted John R. Immer (1950); Ruddell Reed (1961); James M. Moore (1962); Allan Nadler (1965); Cyro Eyer do Valle (1975); James Mcgregor Apple (1977); Richard Muther (1978); James A. Tompkins & John A. White (1984).

In all of its areas of activity, for an improvement project to move from theory to practice, the Production Engineer knows that it is necessary to bring together several conceptually coherent technologies. This reinforces the need to avoid the error of eliminating conceptual issues and to focus only on practical application, since there is a risk of, through a poor choice, infeasible the effective use of all interacting structures, resources and competences that must be harmonious with each other.

The use of experiments carried out using Factory Design and Layout (FDL) methodology is one of the ways to implement PBL approach in Production Systems Project (PSP) course of Production Engineering Department at University of Brasília, developed by Neumann & Scalice (2015) which according to the authors it consists of a structured set of principles and tools and it can contribute to building the foundation of a system of production and operations that, like the heart in our bodies, plays an essential role for the survival of companies.

The importance of this field of study is increasing due to the need for growth of the competitiveness of organizations, taking into consideration that the understanding, the design and development of the Factory Design and Layout in an effective and competitive system are fundamental for the long term success of the organization, since they materialize the strategy of production and they are the basis on which the production is executed.

The themes related to FDL methodology integrate a wide range of knowledge from several areas involved in the rational planning of production activities with effects that will be present over a long term and extend from the structuring of the Business Unit project and go to the Implementation Project, synthesized hierarchically in five macro decision levels, as presented in Figure 1.

Figure 1 – FDL methodology (Neumann & Scalice, 2015)

Phase 1
Structuring

- Strategic Planning
- Business Plan
- Performance Goals
- Performance Indicators
- Production and Operation Strategy

Phase 2
Factory Project

- Product Project
- Definition of Installed Capacity
- Process Project
- Technology Selection
- Location of the Productive Unit

Phase 3 Layout Project	• Process Planning • Informative Project • Conceptual Project • Detailed Project • Execution and Release
Phase 4 Building Project	• Architectural Project • Structural Project • Support Facility Project • Building Construction
Phase 5 Deployment Project	• Machinery Installation • Installation of Material Handling Systems • Pre-operational Tests • UP Pre-operation

PFL methodology is composed of 5 phases and 23 stages. PFL methodology can be visualized as a referential framework in which you can see inter-relationships of these phases, rather than isolated events. In this methodology, all phases influence the time and the costs of operating the productive units and also all of them have as central focus the demands of the market and they can be applied in any type of economic activity.

The work dynamics adopted consisted of orientation and follow-up meetings. At the orientation meetings, the teams discussed issues with teachers in related fields according to the needs of the project. The follow-up meetings aimed to discuss the division of tasks of each component of the team. These meetings were held on a weekly basis.

First phase of PFL Methodology (Structuring) encompasses a set of classic steps used for the design of new companies and this methodology is approached from a systemic vision in themes related to the design of a productive system. At this stage, data and information that aim to analyze if there are basic conditions for companies to achieve high business success rates are obtained and the teams of students are involved in:

- defining the general idea of the productive system;
- defining the context in which it will be applied;
- carrying out preliminary studies of market and production volume;
- carrying out technical, economic and environmental feasibility studies of the project;
- carrying out preliminary studies of the products, materials and production processes;
- defining the purpose and objectives of the production;
- defining the basis and principles that must be obeyed.

Second phase of PFL methodology (Factory Project) focuses on the set of 5 structural decision core for the design of a new Production Unit, considered the main elements for the Factory Project, and the student teams are involved in activities such as:

- design of the production system;
- detailed production volume studies;
- detailing of products, materials and production processes
- determination of the need and purchase of machines, equipment and supplies needed to manufacture and to assemble the products and selected components;
- studies and analysis to the definition of the exact location of the Productive Unit.

In the third phase of PFL methodology (Layout Design) the relative positioning between the areas of the Production Unit is determined accurately and the specific positions of each machine, equipment, inputs and support services are established, and the student teams are involved in activities such as:

- study of the flow of manufacture processes and products assembly;
- determination of the space requirements for production, stocks, auxiliary activities and services;
- design of the departmental layout;
- design of the detailed layout;

- evaluation and optimization of layout.

Fourth phase of PFL methodology (Building Design) involves the design of the buildings and their respective support facilities, including the stage of a plant construction that will cover the activities related to the production of goods and / or services of the production unit. There is emphasis on the realization of the activities involving:

- determination of the necessary constructive features of the building;
- study of the basic types of buildings for industrial purposes;
- preparation of the basic design and of the construction projects of the building and its support facilities;
- building Construction.

Fifth and last phase of PFL methodology is compound by the themes related to the Project of Implantation of the Production Unit, which involves the planning of the installation of the machinery and equipment and all the pre-operational tests needed for the beginning of the project under normal operating conditions. The success of the whole enterprise will depend on the correct scale and perfect performance of its productive resources, and the teams of students are involved in:

- analyzing the specifications of the products and their production process, which will guide the implementation of the various sectors of the production unit;
- describing the actions and procedures for the implantation of the machines and equipment of the productive unit;
- describing the actions and procedures for the pre-operational tests;

3 Conclusion

This article has briefly described how the experiences of learning carried out can contribute to the increase of maturity in the training of Production Engineering students, especially regarding the aspects associated with the need for alignment of decisions between the two levels; the first is related to the preparation of newly formed Production Engineers in the market, whose training develops a professional profile that enables them to manipulate the concepts and techniques for the Factory Design and Layout. In counter-point, the traditional shortage of professionals is due the distance between the industrial reality and the school program of the vast majority of higher education institutions in the country.

The second interesting aspect is that during their training the students apply the tools and knowledge acquired in the academic environment in real cases, expanding their training and inverting the logic in which the company assumes the academic role of complementation of contents, and then the students/professional begin to act in their area and meet the company in their needs.

Factories Designs involve a significant amount of decision areas and time in their planning. Even so, there are problems that are not foreseen and that can occur in the progress of the project, situation that the integration of these methodologies proved very effective for their correct progress.

It has been reported by the teams that there has been a development of a critical sense and a broader view on the various aspects and challenges that must be addressed in the design of a factory. There was also the improvement of teamwork and the development of a conscience focused on environmental and social aspects.

With the joint implementation of the FDL and PBL methodologies in PSP was verified that there is a greater integration among their different phases and visibility of the project as a whole, which allowed a better development of the responsibility for the fulfillment of the agreed activities and deadlines, therefore, it is concluded that it was extremely important for the training of students.

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Engineering Students can use the words "Calculus" and "love" in the same sentence: using active learning the impossible can happen

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Abstract

Teaching Calculus can be one of the most challenging practices in the engineering context for a number of reasons, namely: taught at the beginning of engineering courses, introducing to the student in a critical phase of his/her transition between high school and university, not understanding the meaning of some contents in relation to Engineering. The disciplines of Calculus are responsible for high failure rates and students' dropout. Lectures are predominantly used to teach Calculus in engineering context, with rigid contents centered on the blackboard and in the book. Therefore, students have low interaction with teachers and they have difficult to build their own knowledge and to understand the importance of mathematical methods, and procedures. However, project based learning was used to teach Calculus to engineering students. Students were asked to choose a phenomenon of their Engineering area of knowledge and explain why and how it needs integrals and derivatives to be explained. 127 students from six engineering courses were involved in the experiment. The students were organized in teams and tutored by other professors. This paper aims to describe the experience and analyze the outcomes terms of the perception of learning and development of transversal competences. The evaluation was based on content analysis of the reports delivered by the students. 100% of the groups evaluated the experience as positive. The students used adjectives such as "excellent", "extraordinary" to characterize the experience. In addition, students reported the following learning outcomes: knowledge and understanding; analysis; problem-solving; creativity/originality; communication and presentation; evaluation; planning and organization; interactive and group competences. Some groups reported that, in this project, they created prototypes that they will keep on researching and developing to take these ideas to the market. Yet, in this experience, the failure rate of this discipline that previously was 95% dropped to 5%.

Keywords: Active Learning; Project-Based Learning; Calculus for Engineering; Engineering Education.

1 Introduction

The disciplines of Calculus have an important role in engineer training (Flegg, Mallet &Lupton, 2012). This is the discipline that inaugurates students in understanding and managing mathematical procedures, with a language that can help engineering students analyzing and describing the most diverse engineering problems. The truth is that most students do not realize this positive nuance regarding the disciplines of Calculus. These disciplines are considered to be difficult, boring, inflexible and with no practical application.

In some circumstances, the strategies adopted in teaching Calculus in the context of engineering are mostly repetitions of the modus operandi that mathematics teachers (mostly bachelors) have experienced throughout their formation. Thus, these teachers reproduce what they experience as students. In most cases, as mathematics bachelors, these teachers do not have formal training to became a future professor. As a result many Calculus teachers have no references to turn their practice more effective.

Flegg, Mallet &Lupton (2012, p.718) refers, based on several studies, "there seems to be noconsistent, research-informed, view of how, what, when and by whom mathematics should be taught to engineering students". In fact, a traditional way of teaching predominates in Calculus disciplines in engineering context. Lectures with rigid contents centered on the blackboard and in the textbook are the mean stream strategies. Therefore, students have low interaction with teachers and they have difficult to build their own knowledge and to understand the importance of mathematical methods, and procedures in engineering practice. Yet it is important to mention that the disciplines of Calculus are responsible for high failure rates and students' dropout. Dahl (2017) argues that Mathematics fits in Problem-Based Learning approaches. Nevertheless, there is a lack of studies of PBL including mathematics education for engineers.

This paper aims to describe and evaluate an experience of using project based learning (PBL) to teach Calculus to engineering students which took place at the first semester of 2017. The teacher who led this experience teaches Calculus at this university since 2008. His dissatisfaction with the traditional learning process and huge failure rate in the discipline (95%) in past years motivated him to innovate his practice. To be engaged in the PBL approach, students were asked to choose a phenomenon of their Engineering area of knowledge and explain why and how it needs integrals and derivatives to be explained. A survey was developed with the students who attended this discipline and it was possible to understand its impacts in terms of the motivation to study, the perception of learning, the development of transversal competences and approval in the discipline.

To discuss these results, this paper was organized into 6 parts including this introduction. The second part presents the theoretical framework that indicates the challenges and alternatives to turn the teaching of Calculus an interesting journey to Engineering students and the ultimate considerations about project based learning. The third part is the description of the research procedures. In the fourth part the data discussion is presented. The fifth part is the final consideration of the research. In the final part, the references are included.

2 Theoretical Framework

2.1 Teaching Calculus to Engineering students: challenges and alternatives

According to Kyle and Kahn (2009), in United Kingdom most mathematics teaching comprises formal lectures once more innovative methods are used only occasionally. They added that most assessment strategies rely on formal examinations rather than a wider range of assessment methods. Garzella (2013) found the some reality at a Brazilian University where the discipline of Calculus is compulsory to many courses. At this research, Garzella (2013) found evidences that the teaching of Calculus has the following characteristics: a) the content is inflexible, b) lectures are the predominant strategy of teaching, c) the learning process is centred in the teacher, d) the individualism is predominant (lack of interaction among students and instructors), e) divorce between learning and teaching (teaching is teacher´s duty, and learning is exclusively related to students), e) the traditional way of teaching and assessing is the reflection of an authoritarian ideology.

Teaching Calculus has the importance of help students to understand the multiplicity and variability of nature (Boyer, 1959). As integration and derivation are the main contents, it is possible to assume that the better understanding of them would occur in the mist of experiential learning that can derive from projects, problems or the combination of both active learning strategies. Indeed, the challenge is to help students enter into the process of doing Calculus or applying it to the real world in order to provide a more significant learning process (Kyle& Kahn, 2009).

There are evidences that active approaches are useful to make the learning process more effective, as Prince (2004) argues. One possible strategy, applied to Calculus, is a workshop-style approach. It means getting students to debate and justify proofs within a peer group. It can stimulate, not only the mathematics way of thinking but also other transferable competences such as communication, team work, creativity and autonomy.

Problem based learning is other strategy that can be used in this context, which is one of the most used active learning strategy in the Engineering context (Lima et al., 2017). In terms of concrete teaching strategies, real problems are posed so that students that as a group create solutions to the proposed situation (Haryani, Prasetya, & Permanasari, 2014). Furthermore, the students generate their own examples, visualize, connect ideas or unpack symbols when the instructor engage them in the learning process (Kyle & Kahn, 2009).

Similarly, Kyle and Kahn (2009) suggest mathematical modeling which is a formulation of a real-world problem phrased in mathematical terms. Application is often embedded in atypical mathematics course through well-defined mathematical models that can enhance learning and understanding within individual theory-based modules through adding reality and interest. Through this king of active learning strategy the student can develop several competences such as problem-solving, creativity/originality, communication and presentation, evaluation, planning and organization and interactive and group competences. Meanwhile, they get acquainted with mathematical ideas and techniques.

All these active learning practices mentioned above can clearly enhance students' engagement and understanding in Calculus learning process. Nevertheless, project based learning was chosen in this teaching experience as the active learning approach tool and it will be better explained in the next session.

2.2 Project Based Learning

Projects are finite endeavours with defined goals that rise from a problem, a necessity, an opportunity or interest of a person, a group, or an organization (Barbosa & Moura, 2013). When this concept is used as a pedagogical resource, project based learning (PBL) rises as an AL strategy that allows a student to learn by applying these ideas and concepts (Krajcik & Blumenfeld, 2006).

The PBL is a form of situational learning based on the constructivist findings where the student gains a profound comprehension when he or she gets involved in their knowledge development (Krajcik & Blumenfeld, 2006). This approach has been gaining ground especially in applied science universities due to the student´s necessity to develop several learning competences for the professional environment. It is a technique that provides multifaceted learning experiences as opposed to the traditional teaching method (Lettenmeier, Autio, & Jänis, 2014). Several studies have proved that PBL is an active learning approach that can be organized in several ways. It is important to mention that PBL have a effective impact in the development of transversal skill and consequently in the professional formation of engineering students (Lima, Mesquita, Rocha, & Rabelo 2017; van Hattum-Janssen & Mesquita, 2011; Lima, Mesquita, Fernandes, Marinho-Araújo, Rabelo 2015; Lima, Mesquita, & Flores 2014).

According to Barbosa & Moura (2013), there are three categories for this approach: (i) Constructive project: it aims to build something new by introducing innovations or proposing a new solution to a problem or situation. It has a function, form, or process in the inventiveness dimension; (ii) Investigative project: research development on a matter or situation by applying a scientific method; and (iii) Didactic (or explanatory) project: tries to answer questions such as "How does it work?, "What is it for?, and "How was it constructed?". It seeks to explain, to illustrate, and to reveal the scientific principles of functioning of objects, mechanisms, systems, and so on. To Krajcik & Blumenfeld (2006) , PBL is an overall approach to the design of learning environments. Learning environments that are project-based have the following five key features:

1. They start with a driving question, a problem to be solved; 2. Students explore the driving question by participating in authentic, situated inquiry, which are processes of problem solving that are central to expert performance in the discipline. As students explore the driving question, they learn and apply important ideas in the discipline; 3. Students, teachers, and community members engage in collaborative activities to find solutions to the driving question. This mirrors the complex social situation of expert problem solving; 4. While engaged in the inquiry process, students are exposed to learning technologies that help them participate in activities normally beyond their ability and 5. Students create a set of tangible products that address the driving question. These are shared artefacts, publicly accessible external representations of the class's learning.

Considering all these PBL characteristics, it is possible to conclude that this strategy is broadly used to obtain learning results. For this to happen, it is believed that the teacher must constantly check whether the students have the appropriate theoretical basis for developing a project. As Hibberd (2011) argues, project activities are widely identified as a valuable component of a mathematics teaching. According to him, the potential for enhancement of competences, peer learning and assessment are considerable together with greater efficiency on staff resources. In this way, it is important that the teacher acts as a tutor by following the intermediary results, and by verifying the progress of the work group. Thus, PBL is presented as an alternative to knowledge development that can be shared internally and externally by the university.

3 Research Procedures

This is a descriptive research (Gonçalves & Meirelles, 2002) which is the most appropriate modality to describe the impacts of project based learning strategy in terms of the motivation to study, the perception of learning, the development of transversal competences and approval in the discipline. In order to know in depth the results of the activities performed, the quantitative strategy was used that according to Gonçalves & Meirelles (2002) is more adequate for the quantification and analysis of the behavior of a given population.

To achieve the objectives of the study, a case study was developed that, as Yin (2005) states, can be useful for testing theories and elucidating situations. The case studied was the pedagogical experience of teaching Calculus to Engineering students at the Federal University of Itajubá - campus of Itabira. In this case the project based learning was used with the objective of enhance learning results in terms of the motivation tostudy, the perception of learning, the development of transversal competences and approval in the discipline. It was proposed to students to develop a project in which they should choose a phenomenon of their Engineering area of knowledge and explain why and how it needs integrals and derivatives. In this study, 127 students from six engineering courses were involved in the experiment. The students were organized in teams and tutored by other professors.

Data collection was done through reports the students had to handle at the end of the semester. At this report, the student had to describe: a) how they choose the components of the group; b) how they search for the collaborating professor; c) how they choose the research theme; d) how the choose the Leader and Vice leader, the group organization and the activities; e) Action plan with the research and the presentation (there were 3 presentations in class); f) Conclusion about the project and g) Conclusion about PBL strategy organized by the teacher saying positive aspects and suggestions.

To analyze these data, a content analysis was made in order to identify the impacts of this active learning strategy in the students.

3.1 Description of the activities developed in the discipline

The discipline Calculus 1 is part of the curriculum of the undergraduate courses in the 9 Engineering Courses available at the University of Itajubá - campus of Itabira. The discipline consists of 96 semester hours. The objectives of the discipline are: a) generate the understanding of mathematic concepts of the program, especially analytical and numerical calculations of derivatives and integrals of functions of a variable and its applications, b) develop geometric, algebraic and numerical competences and c) show problem solving tools within the context of engineering courses. Two classes of students were involved in this experience which summed 127 students.

At the begging of the first semester of 2017, the teacher explained the objectives and teaching procedures of the discipline (strategies, activities and assessment procedures). The teacher showed to students how the discipline would occur with the project, lectures and in class activities. Students were asked to choose a phenomenon of their Engineering area of knowledge and explain why and how it needs integrals and derivatives to be explained. The students were organized in teams and tutored by other professors. The phases of PBL approach as described as follows (Table 1).

Table 1. Phases of project based learning used in the discipline Calculus 1

Phase	Discription
Formation of groups 1st class	There were 5 teams in each classroom, from diferent Engineering courses
Choice of Leaders and vice-leaders 1st class	Each team chose a leader and a vice-leader, they had the role of organizing the taskes and solving conflicts. They had the responsability of avaluated the students of his or her group. Each group receive 250 credits which were divided among the members of the teams according their collaboration to the results (as peer avaluation)

Choice of Collaborative Professors 2nd week	Each team contact a professor which was a collaborative member of the team. The colaborative professor was responsable for guiding the group during the development of the project - indicated the theme of the project
1st Presentation 15 class	A 5 minute long presentation designed to atract athention and interesting of the audience about the chosen theme. A report of the tasks developed until this point of the project was asked to the students.
2nd Presentation 28 class	A 5 minute long presentation about the theme of the project. The group should explain the theme derivates related to the project. A report of the tasks developed until this point of the project was asked to the students.
3rd Presentation 44 class	A 5 minute long presentation about the theme of the project. The group should explain the theme derivates and multiples integrals related to the project. A report of the tasks developed until this point of the project was asked to the students.
Final Presentation 49, 50, 51 classes	A 18 minute long presentation about the theme of the project. The group should explain all the job done during the project. A report of the tasks developed until this point of the project was asked to the students.

At this experience, the teams run an investigative project because they were supposed to make a research about an engineering phenomenon by applying derivates and integrals. 28 professors acted as collaborative members of the group, 6 sophomore students and a university technician made the some role helping the teams in the projects.

Half of the discipline grade was due to the project, which was divided in a peer evaluation mode because the leaders chose how they would distribute the 250 credits among students according the collaboration of each member of the team. The other credits were divide in three exams (10 credits in the first test, 20 credits in the second one and 20 credits in the third test). The strategy of linking only 10% of the credits to the first evaluation shows to the students the teacher evaluation style. Thus, a possible bad performance in this first evaluation, would not be a discouraging factor for the continuity of their activities in this discipline. The student can take into account the other possible 90% of the remaining credits.

After each presentation class, the instructor that conducted the discipline gave clear feedback to the students about the communication techniques and about the content of the projects. It was conducted with the clear objective of increase the self esteem of the students. It was important to increase their ability to communicate the results of the project. Another tactic used by the instructor was schedule the presentations after the exams in order to make the presentations in a less tense period.

3.2 Presentation of collected data

Considering the two classes, there were 127 students organized in 23 teams which applied derivate and integral to explain the following phenomena:

1. Optimization of canning process: from the factory to the shelves
2. Shazam Operation: mobile application that recognizes music
3. Support Vector Machine - learning machines technique
4. Vibrations in Machines with Accelerometer
5. Heat Transfer Through Fins
6. RLC - Resistor, Inductor, Capacitor Circuit
7. PID (proportional–integral–derivative) controller 1
8. PID (proportional–integral–derivative) controller 2
9. PID (proportional–integral–derivative) controller 3
10. PID (proportional–integral–derivative) controller applied to Motor Speed Control
11. Calculation of curve area generated by vibrations in an open pit mine explosion through integrals
12. Drone Control Functions
13. Machining of materials

14. Renewable energy
15. PID (proportional–integral–derivative) applied to temperature control in a coffee maker
16. Billets
17. Transport Phenomena
18. RL (Resistor, Inductor) Circuit
19. Flow machines
20. Information by image filter
21. Machining Removal Rate
22. Material Deformation
23. Strobe light

To identify the results of these experience, the final reports delivered by the students were analyzed - with a content analysis technique. From the final reports, we extracted three kinds of terms related to adjectives the students used to characterize the learning experience, the substantives the students used to characterize the learning results they got through the experience and abilities they learned during the experience. Table 2 presents the groups of nouns used by students to say the results of the learning experience. The number after the terms indicates the number of reports that mentioned this noun or expression.

Analyzing the data, it can be noticed that the experience brought a large range of benefits to the students. In some reports the student said that the project was important and useful to them. In two projects, the students said that this project was a first step towards the development of a new product. The students noticed that this experience brought knowledge and great learning (term used in six reports) that occurred outside the classroom. To reinforce this ideia, one group said that this experience brought aincredible and profound learning gain. At another report the students said that this project showed that they are capable of things that seem impossible.

Table 2. Phases of project based learning used in the discipline Calculus 1

Group of nouns used by students to say the results of the learning experience	Nouns used by students to say the results of the learning experience
Perception of learning	knowledge (2), great learning (6), incredible and profound learning, learning outside the classroom, learning easier to be absorbed, learning about the development of the theme, facilitating learning
Improvement of autonomous learning	encouragement to study, incentive to research, improvement for academic and personal life
Opportunity	Opportunity (2), Opportunity to discover the importance of Calculus and its application (3)
Vision and planning competences	broadening horizons (2), achievement of objectives, possibility of continuing future projects, motivation to pursue extension and research projects
Social Relation competences	engagement with the course, network generation, student and teacher relationship (5)
Technical Knowledge	use of laboratories, knowledge of drone technology, contact with senior themes

It can be noticed that the project improved the autonomous learning because tree reports mentioned that the project encouraged them to study and to research. Yet, it improved their academic and personal life. Five reports used the word "opportunity" to talk about the project. According to them, the project was a better chance to understand the importance of Calculus and its application.

In the reports there were references about how the project help them to envision new possibilities to their academic and professional life. The project was a chance to get to know the opportunities of development during the academic life.

Five reports mentioned that the project was important to generate student and teacher relationship. One of the project generated a paper that will be published in a journal. This same project resulted in research project with the collaborative professor. As some reports mentioned, the project was important to allow students to use laboratories and to contact with senior themes.

At Table 3 it is presented the adjectives used to qualify the learning experience.

Table3 : Adjectives used by students to say qualify the learning experience

Adjectives used by students to say qualify the learning experience
Exciting ; interesting (3); stimulating; important (7); extraordinary; wonderful; perfect; great value; big help; gratifying; good; dynamic; very good for growth; generated many results; encouraged the search for new themes; essential; plausible; difficult

Through the analysis of these data, it was possible to perceive that the students had a positive experience. They used positive adjectives to express how the experience was important (mentioned in tree reports) and interesting (mentioned in seven reports) for them. As they said, the project can be considered an "extraordinary" experience that allowed them to grow as professionals and to get many results. At a report, the students said it was a difficult experience. Literally they wrote:

> "We faced some difficulties and at the beginning it was a bit difficult to understand the purpose of the project and how we would begin to develop. But, throughout the course and during the research with the orientations and explanations of Professor Fadul (collaborative professor) and Professor Gilberto (professor of the discipline),it became clearer and we were more excited with our work."

The reports mentioned several competences that the students learned during the project (Table 4). It is noted that there was enough identification of the students with the project that helped them to understand the challenges of a professional engineer.

Table 4. Group of competences developed during the learning experience

Group of competences developed during the learning experience	Competences developed during the learning experience
Research and development competences	Data collection and analysis, preparation of scientific work, search (6) application of scientific knowledge, market research, scientific writing and prototyping (3)
Entrepreneurial competences	leadership (3), effort, receiving feed-back, getting out of the comfort zone, initiative, personal growth, striving for knowledge, drawing goals (2), critical view, organization, developing ideas, overcoming challenges (2), confidence, delegation
Communication competence	public presentation (2), demonstration of learning, idea sharing
Creativity	Problems solution, modeling and troubleshooting, creativity
Social relation competences	group work (9), collaboration, interdisciplinary relationship among group members, generation of network of contacts (4)
Engineering Identity	view on the engineer's career, vision of what it's like to be an engineer, knowledge of important tools for an engineer
Derivative and integral application	visualization of the derivative and integral application (11), relate theory and practice (2), understanding complex issues

The impact of the project on the development of transversal competences becomes even more evident analysing the terms used by the students. It can be concluded that they experienced research and development techniques. Several transversal competences were developed as well such as communication, entrepreneurial, creative, social relation and engineering competences (Lima, Mesquita, Rocha, & Rabelo 2017; van Hattum-Janssen & Mesquita, 2011; Lima, Mesquita, Fernandes, Marinho-Araújo, Rabelo 2015; Lima, Mesquita, & Flores 2014). Even their engineer identity was developed as they reported they felt what it is like to be an engineer during the project.The students reported that the visualization of the derivative and integral application was significant for them because it was possible to integrate theory and practice.

4 Data Discussion

This paper aimed to describe the experience of using PBL to teach Calculus in a more effective way and analyze the outcomes in terms of the perception of learning and development of transversal competences.

Given this, it is possible to infer that PBL was able to engage the students who stated that this experience was "extraordinary" and "extremely important" for them. Through all these statements, it can be concluded that the experience was effective in fulfilling the purpose for which it was proposed - engage the students in an active learning experience. Analyzing the statements mentioned above, it can be concluded that this experience was positive and profound helping the students to develop several transversal competences.

Finally, it is concluded that the use of PBL to teach Calculus fulfilled the educational objective of turning the student an active agent of the learning process. The project was stimulating and made it possible for them to reflect on the importance of their personal development.

In general, the application of the active learning strategy PBL had positive impacts on students' learning, which engaged in studying. As presented previously, the great majority of students reported that the project turned the understanding of the content easier to them. It is relevant to mention that the failure rate that in the previews semesters was 95% dropped to 5%. It shows that the focus of the evaluation process is not only the content in the tests but other important aspects to be analyzed as the quality for the presentations and reports, the analysis depth and the team demonstration of knowledge.

Data showed that this pedagogical experience was good enough to help students to learn a very important knowledge that can open their minds as engineers and business professionals. We also notice, by this research, that Calculus can be a significant way of teaching not only mathematical knowledge but also behavioral knowledge to students.

5 Final Consideration

It can be said that the learning process was more effective using the PBL strategy. One of the points that attracted attention was that student reported they developed their professional profile acquiring competences like communication, creativity, social relation among others competences. It was noted that the method used turned the learning of a difficult discipline a more interesting and pleasant journey to students.

Although the experience was very well evaluated, some improvement can be pointed. In order to value the collaborative professors' work it is important to formalize this dedication which can be useful to help this professor to ascent in their career progression. It is important to intensify the participation of senior students which can be important to improve the integration of freshman into the academic community.

As possibilities of future studies we aim to compare results between disciplines, the expansion of this research for the whole campus besides a research with graduates of the university to verify the impact of the disciplines in the life-long learning.

This study showed that engineering students can use the words "Calculus" and "love" in the same sentence. Learning Calculus can stop being a horror experience because of its high failure rate. It can be a profound experience that freshman, since their first day at university, feel like a real engineering applying knowledge in order to solve real and significant problems.

5 Acknowledgements

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Kart Team: A Laboratory for Engineering Learning

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Abstract

In Brazilian Universities, engineering students are encouraged to be part of teams, which aim to construct vehicle prototypes for academic competitions, such as: Baja SAE, Formula SAE and Formula SAE electric. The proposal to create a team to develop a Kart seems to be a new opportunity and a great challenge for engineering students at the University of Brasilia – campus Gama. Kart is a small, open four-wheeled vehicle, which races on scaled-down circuits. Actually, Karting is commonly perceived as preparatory stage to the higher ranks of motorsports and as a great laboratory for training engineers. The students participating in the project have a prototype and a box at the Kartódromo do Guará. Thus, this paper aims to present the scope of the main project that guided the formation of the team, because composition is essential in the creation of a successful team. For this, students should establish an appropriate team, considering the skills and knowledge of the members concerned. They will be grouped considering the following themes: management and marketing of the team; support group to encourage the creation of teams in other universities; technical groups involved in the powertrain and chassis design. Certainly, the project denotes its multidisciplinary that have a relevant impact in professional formation of engineers.

Keywords: Kart Team; Academic Competitions, Engineering Students.

1 Introduction

From the earliest days, students from diverse fields, including engineering, have been motivated to enter competitions that function as intermediaries between the academic world and the industry. These competitions aim to allow the student to have contact with real engineering situations, thus applying the learning acquired in the classroom, while allowing companies and sponsors to use these competitions to acquire more experienced engineers and better prepared to work in several areas.

In the automotive area, the most prominent student competitions are the BAJA and SAE Formula competitions, both promoted by SAE, the former Society of Automotive Engineering, a company focused on the transportation, automotive, aerospace and commercial vehicles, based in the United States, but has more than 138,000 members worldwide, including Brazil (BAJA, 1997).

According to SAE Brazil, which was set up in 1991, it has the mission to "Disseminate the technology and the progress of mobility", as well as the vision of "Being a reference in mobility technology".

The Baja consists of a small off-road vehicle, designed to withstand adverse terrain conditions, where specifications must follow those proposed by SAE (BAJA, 1997). Already in the Formula SAE competition, which began in 1981 in the United States, with the influence of Ford, Chrysler and GM, the largest American automotive companies, which sought a way to evaluate the performance of students in a competition high-performance vehicle, so that they can acquire engineers to be allocated directly to their teams (FÓRMULA SAE BRASIL, 2004).

Both competitions consist of various tests and design checks and costs, but also marketing presentations, all of which are evaluated by professional engineers with expertise in the field. There are then the static tests, in which the vehicle is presented in detail, there being verification between the equivalence of the project presented previously and the car presented on the day. Finally, there is the dynamic tests. the champion will be the one in which the project presents the best set of general results.

Knowing the importance of these competitions in the training of the engineer is difficult to find a university that does not have a team of Baja and Formula SAE. At the University of Brasilia (UnB) – campus Gama (FGA), we have a BAJA, a SAE Formula electric and currently a Kart team. Unlike the SAE competitions, the Kart team is an extension project within the University of Brasilia.

The Kart project aims to introduce engineering undergraduates in Kart competitions, where they will also have the opportunity to participate, contribute and apply in practice what they have learned in classroom theory for the development of new technologies that can be applied in a Kart by means of a Kart team from FGA / UnB.

In the context of Kart is not yet a modality explored in the Universities and that, therefore, the UnB can be pioneer in its implantation, working with students of the Automotive Engineering being able to integrate new specialties.

2 About the Kart vehicle

The Kart is a four-wheeled but rear-wheel-drive vehicle that may or may not have a body, consisting basically of a chassis, tires and engine. Therefore, the suspension of Kart is not something traditional, being exercised by its own chassis.

The vehicle has a tubular chassis that remains light because it is made of a chrome and molybdenum alloy, to work as a suspension, develop a balance between stiffness and flexibility so that it can deform, absorbing impacts and variations in the lane without breaking or being permanently deformed in an extreme condition, such as a curve.

Depending on the situation and the vehicle, try, most of the chassis has, along its length, where it can be docked, it is possible to insert or remove, change a chassis rigidity, in order to modify the way in which this one deforms. Depending on the situation that the vehicle has to face, a more or less rigid chassis may be preferable, so most chassis has, along its length, locations where rigid bars can be attached, which when inserted or removed alter the rigidity of the chassis, in order to modify the shape of the chassis (Carvalho, 2009).

With that in mind, this item will describe a summary of Kart history, the physics applied in a Kart making a curve and some setups that can be made in the Kart during a competition. All project students will have the opportunity to apply the physics they have learned in the classroom and the knowledge of automotive engineering to perform the best setup for a given track.

2.1 Kart history

In August 1956, the first Kart was imagined and manufactured by Art Ingels and Lou Borelli in the USA. Ingel is a race car builder and he used to drive the simple creation around his local car parks. He used a surplus two-stroke engine mounted on the most basic tubular chassis rolling along on semi-pneumatic tyres.

It wasn't long before others began to show great interest in this fun little invention and by 1957, the first Kart manufacturing companies started appearing in North America.

Demonstrations at some of the nation´s racing circuits further boosted Karting's popularity and the sport took off through the 1960s, '70s and '80s, helped along by the emergence of more sophisticated chassis design, better braking systems, wider tyres and general safety improvements.

The form of indoor circuits hosting low-powered yet fun Karts were created in 1980 and and this made it possible for members of the public to easily have the experience of riding a Kart.

By the mid-1990s it had become the UK's fastest-growing sport and it didn´t take long for the rest of Europe and subsequently neighbouring continents to catch up. These days you'll find Karts circuits in or near just about any major city in the world (Sanches, 2011).

2.2 The Kart – A Piece of Engineering

A Kart is actually a very straightforward piece of engineering, and that's part of its appeal. It is effectively little more than a chassis with a seat, a steering wheel, an engine, a braking system, four wheels fitted with tubeless racing tyres, and no suspension. For all intents and purposes, it's a single-seater racing car distilled to its core components – any simpler and it wouldn't work. But it doesn't mean that a race Kart doesn't a degree of complexity when it comes to, say, set-up.

The main differences between a car and a Kart are:

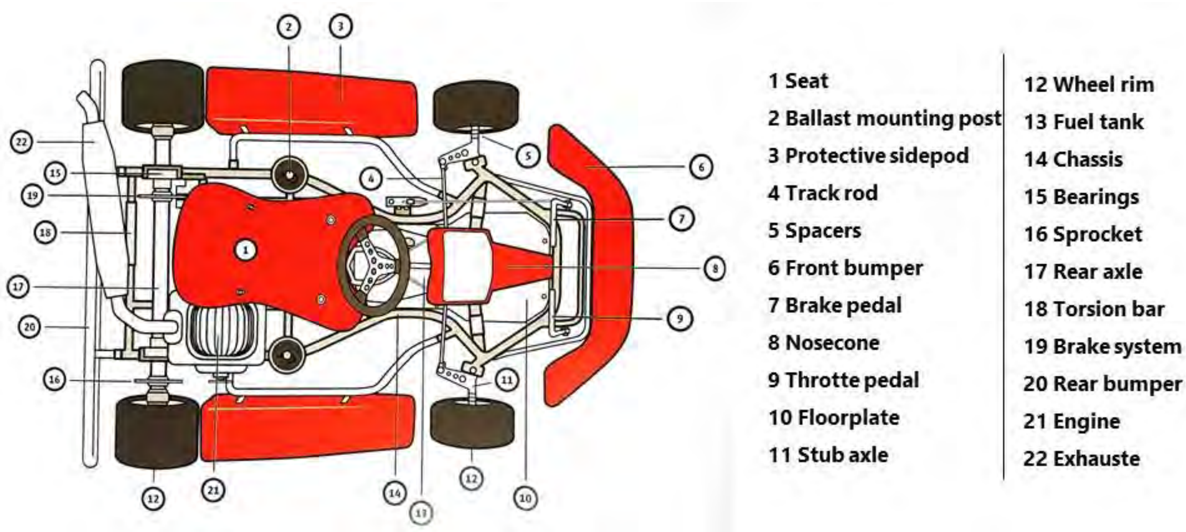
- The Kart has no differential, but only one rear axle;

The Kart has no suspension components such as springs and dampers.

These two main features of the Kart influence the steering and chassis adjustment.

A typical Kart layout is showed in the Figure 1.

Figure 1. Typical Kart layout (Sanches, 2011).



The Kart, although small and seemingly simple, offers a very wide range of chassis set-up options that improve performance on the track. You can adjust, for example, width, height, alignment, rigidity, transmission ratio, calibration, among other things, which will be described in item 2.4.

Regarding the engine used in Karts, the type of engine varies according to the race category, however most of these engines are manufactured exclusively for Karts.

The 125cc two-stroke, air-cooled, clutch less and non-electric driven engine for many years was the engine that dominated the market both in Brazil and in Europe. However, since this engine turns high like a Formula 1 engine (21,000 rpm) and has a torque of 27 kW and a horsepower of 41 horses, it has a shorter durability (Carvalho, 2009).

With the pursuit of greater durability and technology, the industry is developing several types of engines.

Currently the engines can be two- or four-stroke, with or without clutch, with or without gear, with or without electric, air or water cooled, and which are 100 to 400cc and 5.5 to 44 horsepower. On the other hand, there is also the "Kart shifter" in which it has an engine with gearbox, water cooling and electric start, in which this type of Kart has many more components for maintenance.

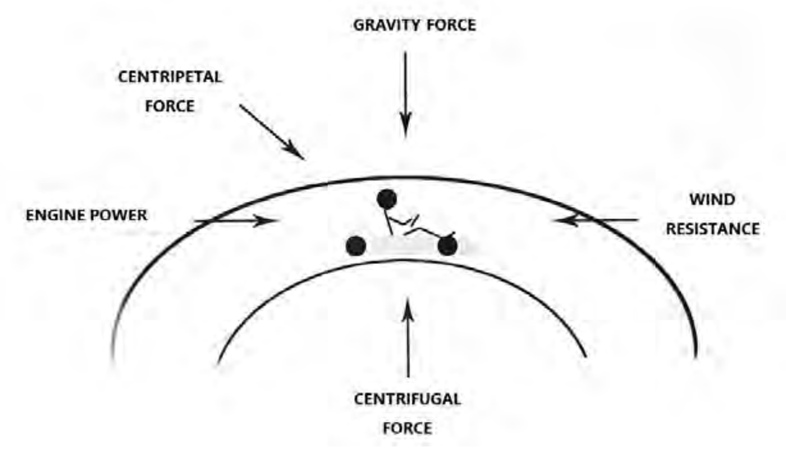
The Faculty of Gama (FGA / UnB) has a competition Kart of the brand Kart Mini year 2012, with engine of four-stroke and 18 horsepower, prepared by the company RBC and has 4 new tires of red mark MG. Therefore, students entering the team may already be meeting and working directly in a competition Kart to achieve the project objectives together with the teachers.

2.3 Physics Applied to Karting

The student involved in the project, when making a curve with a Kart, may be applying in practice various concepts of physics taught in the classroom.

The application of physics, for example, when the Kart is making a curve in the track, is of great importance to define the best setup of the Kart, because at the moment there are several forces, as shown in Figure 2.

Figure 2. Forces of physics applied to a Kart (Carvalho, 2009).



The definition of each force applied to the Kart shown in Figure 2 are:

- The centripetal force: is the force that acts on a body so that it makes a curve, being responsible for the change of speed direction. The direction of this force is inside the curve;
- Force of gravity: it is the force of nature that is a vertical acceleration, which pulls (or pushes) the bodies towards the center of the Earth. The higher the altitude, the lower the gravitational force and the lower the atmospheric pressure;
- Centrifugal force: it is the force that pushes a body out of the curve. The smaller the radius of the curve (the more closed curve), the greater the centrifugal force. This force decreases as the angle of the curve increases and when the angle is zero that force is zero.
- Wind resistance: it is a totally variable force of nature. Depending on the direction and intensity of the wind, the rider will have to modify the track layout and the breaking point;
- Engine power: is the force that will fight against all other forces to make the Kart move.

There are other physical factors that students learn in classrooms and can apply in practice such as calculating the centre of gravity (CG) of the Kart (centre of mass of a body), traction (action of a force that moves an object), aerodynamic drag (force that is opposed to traction and is caused by the resistance of the air to an object) and balance/stability (when the weight distribution is homogeneous).

2.4 Kart Set-up

Trying out new set-ups and gaining time is an enjoyable part of process as long as you accept that the biggest improvement you can make to a Kart is adding a good driver.

There are basic rules for setting up a chassis, but the fine tuning is done according to the characteristics of the equipment and the driver. Every Kart, and every driver, are different, and each requires a setting that fits individually.

In general, for a low-speed track a softer chassis is used so that the pipe can bend more and thus the curve can be circumvented with better efficiency. Already on a high-speed track, a harder chassis is used, because if it folded too much would leave the Kart glued to the ground and therefore slower wasting time. But all this can vary depending on the conditions of the track and temperature (Sanches, 2011).

Here are some basics to start how to do a Kart set-up:

Caster: Caster helps keep a Kart from wandering in a straight line due to the torque value created by the difference between the angle of the spindle in relation to an imaginary vertical line running through the wheel. The greater the caster angle, the more difficult it becomes to turn the wheel. Caster is fundamental to enabling a Kart to turn by allowing the inside rear wheel to lift (Figure 3a)

Camber: Camber represents the amount of lean applied to the wheel and affects the tyre's contact patch during cornering. This works in conjunction with caster to help a Kart change direction quickly and in capable fashion. Camber can be described as the vertical inclination affecting the front wheels. When looking at the front of the Kart, negative camber is seen on a wheel sloping towards the Kart, while positive camber will have the wheel leaning towards the outside of the Kart. Its purpose is to maximise the tyre's contact patch during cornering (Figure 3b).

Toe: Toe refers to the difference in distance between the front and the rear of the directional tyres (Figure 3c). Most Karts use zero toe, meaning the front wheels are parallel to each other, or fractional toe-in (the wheels point inwards at one another). Toe-out is used during wet races, when turn-in needs to be exaggerated and the resulting scrubbing keeps the tyres at a better operating temperature, thereby increasing grip. So, toe-in primarily affects straightline stability, while toe-out improves turn-in ability.

Figure 3 shows the three main setup of a Kart.

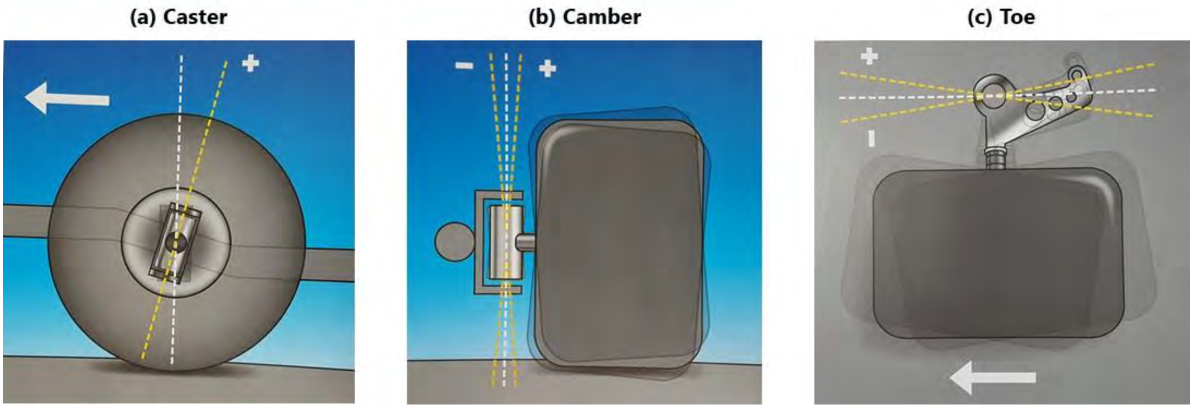


Figure 3. Some kinds of set-ups of a Kart (Sanches, 2011); (a) Caster; (b) Camber; (c) Toe.

3 Kart Team Contributions in the Engineer's Training

Some of the practical applications that engineering students can apply in a competition Kart are described in item 3. However, the design of the Kart team also includes other important activities in the training of the engineer, especially in the training of the automotive engineer and which will be described here.

First, the engineering student at UNB / FGA who are interested in participating in the Kart team will have to go through a selection process. The selective process is carried out by ENGRENA solutions in engineering, which was created in 2015, as the Junior Automotive Engineering Company of the University of Brasília. The company is composed of undergraduate engineering students from several semesters in order to promote a diversity that helps in the search for the best solution to the presented problem. The candidate is evaluated in three stages. The first stage consists of curricular analysis, the second stage consists of a group dynamics, and finally in the third stage an interview is conducted with the candidate who was approved in the previous stages.

The undergraduate engineering students who are part of the Kart project will have all the necessary support to carry out their activities by the participating teachers of the project and responsible for their respective activities.

Learning how a Kart team works will be done through visits to Kart competition events, where students can follow a professional Kart competition team inside the pits as they behave and work during a competition.

All maintenance and assembly / disassembly of the Kart engine will be carried out by the students themselves, where they will be able to put into practice all their knowledge acquired in the classrooms about four-stroke combustion engines. Also with this activity, students gain more experience and knowledge about mechanical tools for such activity.

Through the teachers the students will also be encouraged to develop new technologies or they will be able to develop a project of Kart chassis different from what exists in the market, among other things that could turn out works of conclusion of course (TCC) or even publication in scientific events.

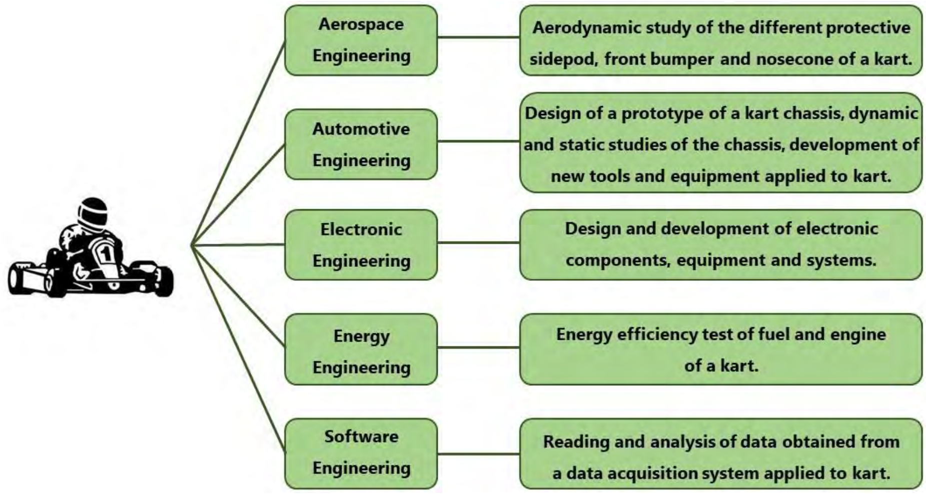
The project activities are:

- Propose the first Kart competition event between universities in the Federal District: The Federal District has three Kart tracks approved by the CBA / FIA, where Kart competitions are held annually. With this purpose, this activity aims to propose and promote the first Kart competition event in DF among universities.
- Participation in Kart competition events: This activity involves the participation of the students as a spectator or as a participant in a Kart competition in Brasilia.
- Motivation at UnB on Kart: This activity consists of the participation of events and shows at UnB, publicizing and motivating the students to participate in the Kart project.
- Kart Engine Assembly and Maintenance: In this activity students will have the opportunity to assemble, disassemble and make the necessary maintenance in a four-stroke Kart racing engine.
- Kart design: The Kart design can offer an excellent design platform, with great challenges in the areas of structural performance (rigidity and weight), dynamics (chassis adaptation to the needs of the piloting), NVH (comfort and ergonomics), among others that can be applied in discipline of Vehicle Structures Project offered by the Automotive Engineering course in the eighth period. This is a complementary study to the disciplines of the project chain that were offered to the students of this course, which includes advanced aspects of materials resistance, CAD / CAE, product engineering, test engineering, among other practices required by industry for a good execution of projects of bodies and other vehicular structures.
- Kart engine course: This activity consists of a mini course of operation and preparation of a Kart racing engine, where all types of engines and their respective performances will be presented through theoretical and practical classes.
- Kart driving course: This course will consist of theoretical classes on piloting, involving theories such as the best course, position of guiding, braking, acceleration, overtaking, among other items. In addition to the theoretical classes, students will have the opportunity to test, what they have learned in theory, in a Kart simulator that already exists in UnB / FGA.
- Participation of scientific events: Through this activity the students participating in the team who have developed or tested something in the Kart and who have obtained interesting results will have the opportunity to present their results in scientific events.
- Study of the rigidity of the rear axle of the Kart: It is proposed, in the present project, the specification and analysis of the influence of the rigidity of the rear axle of the Kart in the dynamic reactions of the same one. In this sense, a static evaluation on finite elements can be performed considering the mechanical properties of materials usually applied to this component. It is clarified that the characterization of the material can be performed in the laboratory, according to pre-established standards using ready-made test bodies, according to usual norms. Then, instrumentation can be done on this axis in an existing vehicle, which will allow the acquisition of active displacements during vehicle traffic on the competition track. This signal can be taken to the software as a history data, which will allow a more realistic evaluation of the efforts in this axis.

The evaluation of each student will be held at the end of each year, where students should prepare a report of everything they did on the Kart team throughout the year they attended. This report can be individual or group if it is required for a particular activity.

The general idea is to create conditions for a learning-friendly environment by providing activities that can integrate students from various engineering areas where students learn to work in groups (such as team) and develop the ability to reason quickly and efficiently which is one of the benefits of a competition. Figure 4 shows a schematic of this integration between the engineering courses of the University of Brasília (UnB / FGA) and a brief description of what each course can contribute to the Kart project.

Figure 4. Scheme of the integration between engineering courses and their respective possible contributions to the Kart project.



4 Final Considerations

The Kart team project already consists of a competition Kart and a box located inside the Kartódromo do Guará in Brasilia (Figure 5). The box works like a laboratory for the students because it has all the necessary structure to work in the Kart. In the Kart track the students have the opportunity to test the Kart after some modification.

Figure 5. Photo of the Kart and photo of the box located in Kartódromo do Guará.

Having all the structure available, the students of the team have already begun to work with some of the activities already mentioned in item 3. One of the students is doing his TCC with the theme of the activity study of the rigidity of the rear axle of the Kart. Another group of students are starting a project of a low-cost telemetry system applied to a competition Kart. Also, another group of students had the initiative and idea to develop and build a portable bench dynamometer to be used before competitions to gauge the power of the engine. The design of a Kart has already been included in the discipline of Vehicle Structures Project offered by the Automotive Engineering course.

In addition to these activities the students of the team are making the dissemination of the team in social networks, in UnB events and within Kartódromo do Guará. The next step will be to try sponsorships for the team.

Thus, the Kart team project has been very promising for better training of engineers making it best observed by industries in the future.

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Factor Analysis of the results of a Project Based Learning course involving Production Planning and Control Techniques

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Abstract

The project-based learning (PBL) approach has been a part of the University of Brasilia's curriculum from the inception of its Production Engineering program, mainly through the PSP (Production Systems Project) course. The PSP4 course - one among eight courses that utilize the PBL approach - is the subject of this study, in which we present a set of analyses of the projects developed between 2013 and 2016 summing up 45 projects. The projects involved real-world problems, related to public or private sector enterprises in Brazil's Federal District. The conducted analysis identifies the PPC (Production Planning and Control) techniques used to achieve project objectives, and performs a Correspondence Analysis involving the fragmentation of the data's total inertia, considering the profiles for the homogeneity hypothesis. A small sample of dimensions used for representing the whole variety of data was identified using the SAS® package for data analysis. Subsequently, a two-dimensional graph was constructed by using the value of the overall grade (NG) assigned to a particular project, along with all 36 themes, tools and techniques used throughout the 45projects. Results present the most representative techniques for explaining values near NG as well as the techniques responsible for understanding data dispersion.

Keywords: PBL, case study, Factor Analysis,

1 Introduction

Concerns about traditional methods of education have been demonstrated by many universities through different studies. Teaching methodologies are questioned, especially in the engineering field, because engineers are traditionally required about knowledge in science and technology in the conventional methods, without the development of a systemic view and certain skills to solve complex problems while they are in graduation period.

According to Tobin, Kahle, Fraser, (1990) and Prince & Felder, (2006), the increase of students' lack of interests and motivation have been noticed because of traditional teaching methods, also known as deductive approaches, since teachers usually motivate students' focus and efforts only on exams and tests, which leads to disappointing levels of learning retention.

Considering the observation of those problems, many universities are developing new teaching methods, considering practical application of knowledge along the course, and before graduation. According to Taajamaa, et al. (2013), engineers must not develop only purely technical proficiencies, but is essential to advance on interdisciplinary skills, cooperation and project management. In this sense, the project-based learning (PBL) approach has been widely applied as a teaching and learning strategy (De losRíos-Carmenado, López and García, 2015; Reis, Barbalho and Zanette, 2017; Barbalho et al., 2017).

Focusing on the improvement of student's knowledge retention, and in a better and innovative relationship between theory and practice, the PBL approach was implemented in 2009 in the undergraduate Industrial Engineering's program, in the University of Brasilia (UnB) (Prince & Felder, 2006; Lima et al., 2012; Zindel et al., 2012; Barbalho et al, 2017). The course encourages a professional interaction with several different environments, increasing the abilities of undergraduate students to deal with real world questions.

Quoting Zindel et al. (2012), external partners, public or private companies, are invited to present problems that will be managed in group projects by course alumni. The proposed approach (PBL) will promote students' learning by means of assisting this external third party with their internal improvement projects.

In this context, this paper's goal was to use data from the course termed Production Systems Project 4, which runs concurrently to production planning and control discipline, to perform a factor analysis. These data were gathered from three years of projects students were working on this PSP4 course, part of the PBL approach used in the Industrial Engineering course of University of Brasilia. The purpose is to build a first, exploratory model for helping the planning activities to teach production planning and control in an project based learning approach.

2 Project-Based Learning

According to Soares, Sepúlveda, Monteiro, Lima, & Dinis-Carvalho, (2013), the development of students' skills has been widely employed by teaching approach based on Project Based Learning (PBL), through practical application of academic concepts on real-world situations, throughout University's program.

The PBL approach introduces students with a real demand that needs to be managed, increasing their individual motivation (Balve & Albert, 2015). The student transitions from a passive role, in which he or she receives knowledge, to a more active stance.

With the accompanying guidance of the course's professor, students will develop their knowledge through active learning, interacting, and independent or collaborative teamwork (Taajamaa et al. 2013). Based on these studies and ideas, students will not be merely passive recipients of knowledge. They will experience a situation like what will face in their professional lives, hence preparing them to the job market.

The Project-Based Learning approach starts with the performance of one or more tasks that lead to the development of a product, which results in a report that summarizes the procedure that was applied (Prince & Felder, 2006). Based on Thomas (2000), PBL projects can be organized on one or more thematic units. Through this aspect of knowledge construction, it is observed that learning could foment students' motivation and interest, providing them with a greater sense of satisfaction (Frank, Lavy & Elata, 2003)

As reported by Aquere et al. (2012), using multiple subjects in an engineering education can provide different perspectives about several issues, with the study directed to the ability to solve real-world problems, as well as the development of communication skills and teamwork. Also, according to Taajamaa et al. (2013), it is now understood that the development of abilities and competences are essential to an engineer's background, which PBL is considered as being an approach that can assist on this advancement.

There are various studies on the use of the PBL approach. The results, with regards to improvements in learning, resulted in the increasing rate of retention of knowledge, also have been perceived as positive for the universities themselves. Likewise, according to Aquere et al. (2012), many benefits were recognized by the experience acquired in the application of technical knowledge in real-world issues by students, such as improvements in their project planning skills and abilities related to leadership, communication and teamwork.

It is important to point that much of the research explores students' own perspectives regarding the improvements noticed by learning through solving real-world problems using the PBL approach. In this research, following achieves of Barbalho et al. (2017) greater emphasis is being given on studying the impact of the projects' technical characteristics on their outcomes particularly studying the correspondence between technical contents and the general grade of students in 45 projects on the field of production planning and control (PPC).

3 Methodology

This research utilized a case study approach (Yin, 2010) as an object of investigation to perform a deeper analysis. The PSP4 course mentioned before and structured according to the PBL approach will be studied. Qualitative and quantitative data was gathered from the different projects, since grading datasheets, archives of final reports and project´s presentations, to reflections of the course's professors, who are also the authors of this study.

From the first semester of 2013 to the first semester of 2016, the projects presented by the students were evaluated, considering their final reports and presentations. We did a content analysis (Dane, 1990) to identify the specific technical knowledge applied and to characterize both the assisted company and the problem addressed.

The grading datasheets from 2013 to 2016 were collected and stored, totalling 45 different projects, with each semester generating a specific datasheet. These data were analysed, formatted, and consolidated into a single document containing all projects and their respective grade summaries.

The qualitative data from this documental analysis was inserted into a different datasheet, in which a binary classification was considered for each technique used by the project teams, namely "1" when the technique was used, or "0" when it was not. A quantitative analysis was then conducted regarding the techniques of the anchor course that served as a basis for the projects carried out.

Eventually, a new datasheet was created, composed by data from the two previous sets. This datasheet was used for the application of deeper statistics using the SAS® software, to perform a Factor Analysis. This study complimented Barbalho et al. (2017) adding the main dimensions to explain data dispersion when taking into account the general grade of a project and the PPC techniques used. For Factor Analysis we used the traditional procedure as follow.

By notation, collect all of the p variables X into a vector $\boldsymbol{X}$ for each individual subject. This will be a random vector, with a population mean. Assume that vector of traits $\boldsymbol{X}$ is sampled from a population with population mean vector, $\boldsymbol{\mu}$, where $E(X_i) = \mu_i$ denotes the population mean of variable i.

Consider k unobservable common factors $F_1, F_2, \ldots, F_k$. The *ith* common factor is F_i. Generally, k is going to be substantially less than p. The common factors are also collected into a vector, $\boldsymbol{F}$. The factor model can be thought of as a series of multiple regressions, predicting each of the observable variables X_i from the values of the unobservable common factors F_i:

$$X_1 = \mu_1 + l_{11}F_1 + l_{12}F_2 + \ldots + l_{1k}F_k + \varepsilon_1$$

$$\vdots$$

$$X_p = \mu_p + l_{p1}F_1 + l_{p2}F_2 + \ldots + l_{pk}F_k + \varepsilon_p$$

The variable means μ_1 through μ_p can be regarded as the intercept terms for the multiple regression models. The regression coefficients l_{ij}, loading of the *ith* variable on the *jth* factor, for all of these multiple regressions are called factor loadings. These will be collected into a matrix $\boldsymbol{L}$.

The errors ε_i are called the specific factors, where ε_i represents the specific factor for variable i, and the specific factors are also collected into a vector $\boldsymbol{\varepsilon}$. In summary, the basic model is like a regression model in which each of response variables X is to be predicted as a linear function of the unobserved common factors $F_1, F_2, \ldots, F_k$, the explanatory variables. Therefore, the k unobserved factors that control the variation among the data.

Generally, the matrix notation is shown in this form:

$$\boldsymbol{X} = \mu + \boldsymbol{LF} + \varepsilon \qquad (Eq. 1)$$

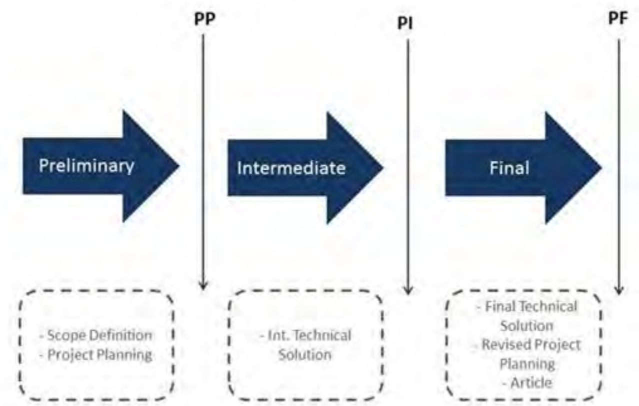
Next, we present our case study results.

4 Results

Considering University of Brasilia's Industrial Engineering program, the PBL approach is driven by a set of disciplines called production system project (PSP). Each PSP course is related to one or more anchor course in a specific semester, and projects are carried out in accordance with the theme of their respective anchor courses, involving the discussion of practical problems from external agents, with a support of specific project management methodologies used in order to solve them (Figure 1). This approach stimulates students' learning through the search of solutions and project proposals aimed at addressing the issues of external agents. No related content is presented to alumni before each PSP course. Their anchor disciplines are ministered alongside as co-requisite course, and as deeper concepts and techniques are scheduled for the last classes, students commonly utilize self-learning as a method for achieving project solutions.

The PSP4 course is related to Production Planning and Control (PPC) discipline, as a co-requisite. The PPC course in the University of Brasilia's Industrial Engineering program is a unique discipline, where students review production system design methods according to Slack, Chambers & Jhonston (2009) as well as theories related to demand forecasting, capacity planning, inventory management, scheduling and shop floor control (Sipper & Buffin, 1997; Vollmann et al, 2004). Although students in the PPC course need to approach real-world companies, the course's focus is theoretical. The professor assigned to PSP4, who commonly also ministers the PPC course, advises students in the implementation of effective actions aimed at solving a real-world PPC problem, as presented by external partners. The PSP4 course is structured around the assessment, by faculties, of the work accomplished by students, as presented in Figure 1.

Figure 1. PSP4 basic grade structure



The PSP4 course grading structure consists of three grades, in which students are assessed based on the quality of the work presented in terms of a technical report and a formal presentation. The first grade is related to the Preliminary Project (PP) and consists of the evaluation of the Project Management Plan (PMP). This plan is evaluated according to the PMBOK Guide's five areas: Scope, Time, Communications, Stakeholders and Risks. Students are instructed to develop a project plan using the sequence established by the PMBOK Guide©, in which the Work Breakdown Structure (WBS) consolidates the scope, serving as a basic input for the preparation of the schedule and other technical elements of the project plan (Project Management Institute, 2013).

As the Production Systems Project course is presented as a co-requisite to PPC, meaning that students do not yet comprehend all the contents that can be applied to a specified problem, it is emphasized that the main output of this step is a well-defined scope.

The second grade is assigned to the students based on the Intermediate Project (PI). While the Preliminary Project focuses on the project planning stage, involving the definition of its scope, schedule, and risk analysis, the objective of the PI is primarily to observe the technical development of the tasks, in relation to the initially proposed scope. Therefore, if the project has a purpose of, for instance, analysing the alignment of the company's share price with its' external demands, the Intermediate Project must present the use of inventory analysis techniques, such as a Pareto analysis, the identification of inventory costs per unit, demand analysis, and identifying seasonality, trends, and randomness, depending on the previously defined scope. As already mentioned in relation to the Preliminary Project phase, in this case professors also give their support in solving problems arising from misunderstandings by students who have not yet attended the previous PPC course classes in PPC.

The Final Project (PF) consolidates the assignment based on the elements developed in the Preliminary and Intermediate phases. As for the PP, the project plan is also analysed. In this case, students must indicate the differences between the initial plan and the outcomes. As such, the last version of the project's scope is compared to the initial version. The same follows for other elements, such as the project's schedule, communications and risk planning, and stakeholder definitions. It is required that students present a comparison of the changes made between the preliminary delivery's baseline and the project's final configuration. However, the main result of the final project is the content of the technical assignment executed by the teams. In this sense, the concepts of Production Planning and Control are thoroughly analysed and compared with the results achieved by the teams. Concurrently with the final Project, the PPC class is, at this point, concluding its activities. All of students' coursework are reviewed in class, (and the final PCP test might be administered), which facilitates the technical discussion of the results. In addition to the revised project plan, students compose an academic article, detailing the technical tasks performed for the external partner.

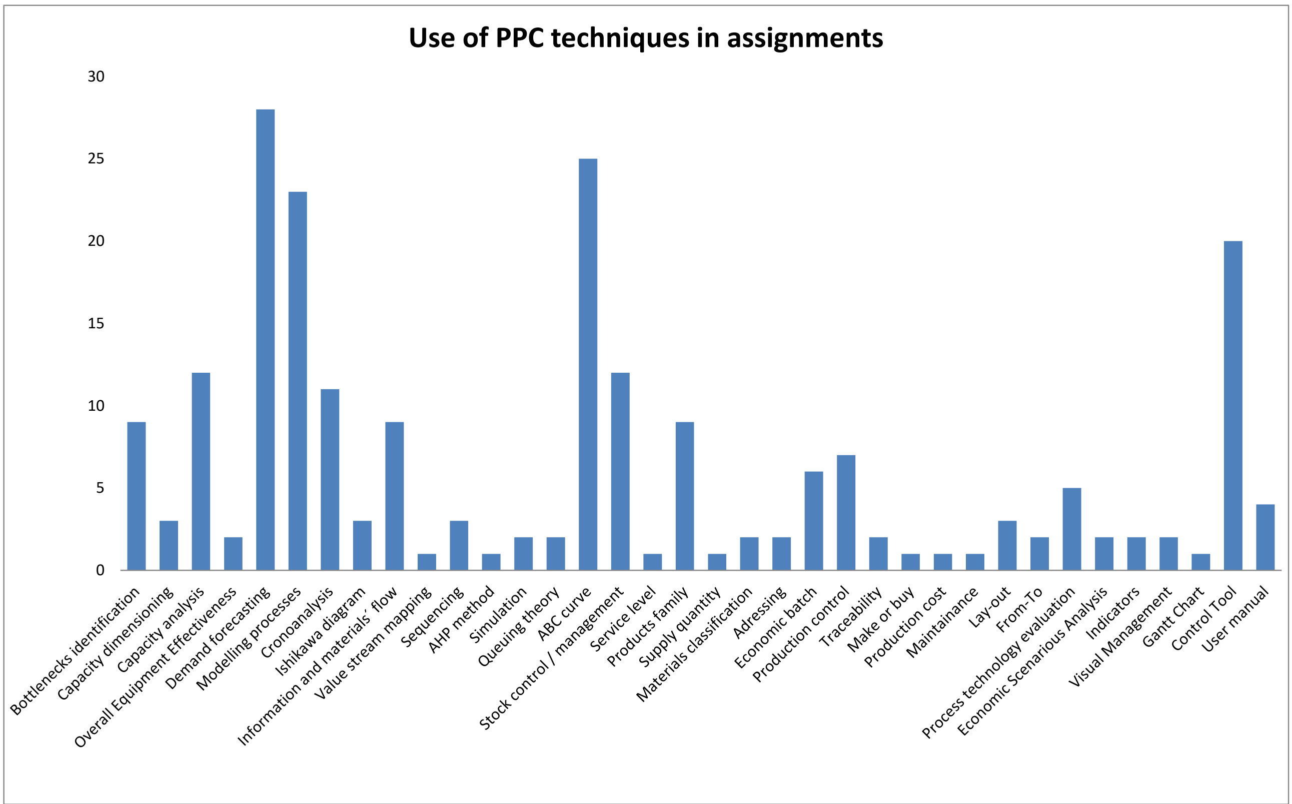
To conclude, the Final Project presentation occurs with the presence of the external partner, which reflects on the overall results, in the presence of both students and the course's professors, with the resulting feedback being incorporated into the final evaluation.

4.1 A review of concluded PSP4 projects

The PSP4 course has been ongoing from the first graduate class of the University of Brasilia's (UnB) Industrial Engineering program, starting in the second semester of 2012. Data from the first semester's class was not considered, as the course's structure was at that stage not consolidated in the manner shown in the previous section. Considering the period from 2013's first semester to 2016's first semester, seven PSP4 courses were undertaken, totalling upwards of 204 students who have accomplished the activities previously detailed. Overall, 45 projects were analysed.

As described, projects were analysed to be characterized according to the used production planning and control techniques, as well as the main contributions of the project to the organizations, as required by their owners. The graph in Figure 2 presents the techniques used in the evaluated projects.

Figure 2. Use of PPC techniques in the assignments



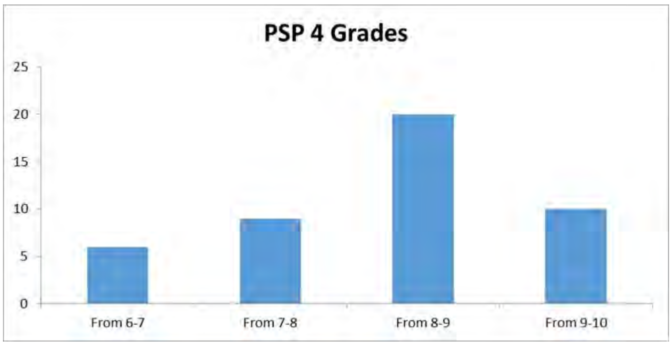
The main techniques used in the assignments were demand forecasting and ABC curves. Their application was justified by the fact that the projects usually focus on the analysis of the companies' production data. The basic data was related to production demand, and one of the main analysis performed has, as its objective, the identification of the company's main products, in terms of volume, revenue or costs. Process modelling techniques are also heavily emphasized, with a predominant use of qualitative methods for analysing production processes (such as mapping techniques), although several projects have been done based on data analysis. Quantitative data – such as measuring the time elapsed in each manufacturing process - were collected throughout the production process, especially in cases in which capacity evaluation and planning was the teams' focus.

4.2 Grades attributed to projects

The consensus among those who experience active learning holds that the grade is not as important as the process of working in teams, and the opportunity to interface directly with real clients (De los Rios-Carmenado et al. 2015). In essence, a grade is a summary of the evaluation that professors attribute to projects, according to their results. As such, initial analyses were conducted regarding the projects' grades. The first of these serves to relate the given grades to some of the characteristics of the external partners themselves.

Despite of the fact that PSP4 projects are performed in teams, the grades are individual for each student. Two faculties share the process of assigning grades in form to reduce subjectivity. The results have been positive for alumni development. From a group of 204 incoming students, only 11 failed the courses, representing 5.4% of total. However, individual grades have mostly been used as stimuli for students' efforts. The actual effective result was tied to the outcomes from each team. Consequently, in order to analyse data from PSP4 courses, only the overall team grades were considered, notwithstanding the merits of peer evaluations and individual grades. Figure 3 presents the general grades (GG) assigned to projects developed during the courses.

Figure 3. General grades assigned for projects



Of note in Figure 3 is the fact that the majority of assigned grades lies between 8.0 and 10.0, in spite of the excellence, which is represented by grades from 9.0 to 10.0. Additionally, no grades below 6.0 were given, which denotes the high standard of PPC applications performed by student groups.

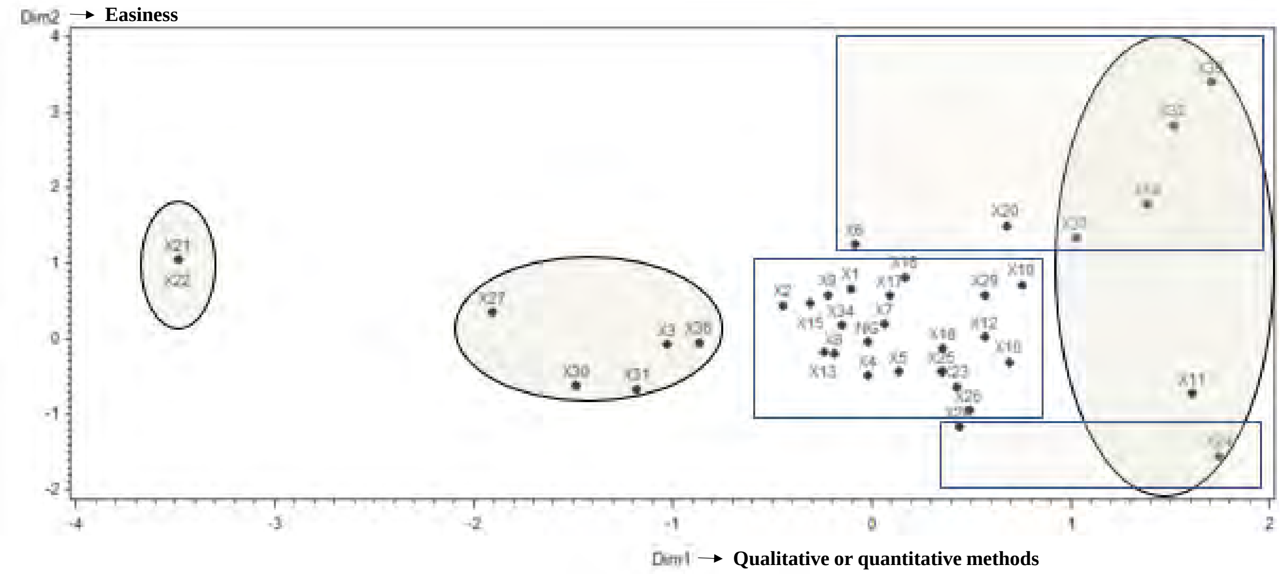
4.3 Factor Analysis

Considering the categorical nature of the variables under study, a Factor Analysis was performed to identify the small number of dimensions that best represent the diversity provided by the data set under study (Johnson and Wichern, 2007). By using the SAS® software for statistical analysis, it was possible to verify the formation of homogeneous subgroups, which was possible by decomposition of total inertia, or the total variation.

The graph representing the inertia of the two major dimensions was constructed by using the value of the overall grade (NG) assigned to a particular project, along with all 36 themes, tools and techniques used throughout the 45 projects. The result is in Figure 4 where the ellipses represent the subgroups that determined the dispersion in the first dimension (Dim1), which best represents the dispersion of the data. Likewise, the rectangles represent the subgroups that determined the dispersion in the second dimension (Dim2), the second-best representation of the data set dispersion.

Analyzing the abscissa, one can notice the outstanding contrast between the variables "simulation" (X21) and "queue theory" (X22), as well as the variables "scenario analysis" (X3), "sequencing" (X27), "Gantt graphic" (X30), "cost of production" (X31) and "chrono-analysis" (X36), with the variables "visual management" (X11), "development of the production control tool’s manual" (X14), "service level" (X24)," traceability" (X32), "maintenance " (X33) and "make or by analysis" (X35).

Figure 4. Projection of dispersion of the analyzed variables into the two main dimensions



This dimension can be called qualitative-quantitative methods. At the negative scale, we can see the grouping of variables with a quantitative approach to the problem of product planning and control through optimization methods. At the positive range of the scale, closer to the value of the overall grade of the projects, the "traceability", "maintenance", "visual management", "development of the production control tool’s manual", "make or buy analysis" and "service level" variables are present. None of these variables incorporate an optimization element, although mathematical models are basis for "make or buy analysis" or the identification of service levels.

The second dimension presents a dispersion level similar to the first dimension. This dimension presents the contrast between "process technology evaluation" (X6), "development of the production control tool’s manual" (X14), "value stream mapping" (X20), "traceability" (X32), "maintenance" (X33) and "make or by analysis" (X35), with the variables "visual management" (X11) and "service level" (X24). This dimension may be comprehended as transitions between easier techniques for the final user to understand, such as visual management and service level, both elementary concepts to perform and the no need for more accurate know how to develop them. On the other hand, there are more complex techniques whose relationships with other analyzes are more intricate, such as value stream mapping, as an example that aggregates chrono-analysis’ elements, process mapping, material and information flows and capacity analysis. Such complexity occurs in the evaluation of process technologies or in the make or buy studies.

The rectangle at the centre contains most of the techniques, as well as the value of the final grade for the projects (NG). The grouping of variables in this area, especially around NG, indicates what is generally done for a project undertaken in a PSP4 course. These variables do not contribute to the data set dispersion.

5 Final Considerations

This paper involved an analysis of a PBL course in the Industrial Engineering program of a Brazilian public university. Initially, we presented the constituent elements of the course and its grading structure. There was a set of basic techniques used in these projects, regardless of the approach: demand forecasting, ABC curve, process mapping and control tools.

Factor analysis identified two explanatory dimensions for the projects. The first concerns qualitative to quantitative approach for operations improvements. The second dimension reflects a more complex or easy-to-understand concept for process improvement. At the centre, near projects´ global grade we have techniques more used for diagnosing and understanding the production system of companies studied, while at extremes for both dimensions we have applied techniques for process improvements.

Our data allow suggesting that if a teacher is using active learning in a PPC course, he must consider balancing process improvements techniques. Independent on external agents´ problems, a set of analysis are mandatory for problem clarification and proposal of solutions. After, a set of techniques can help the project execution. Their profile can be qualitative or quantitative techniques, according the project´s purpose, and the easiness for both, understanding and execution must be taking into account especially when client´s interface is increasing or if the external agent wants to put the project´s result in scene.

There are important limitations seen in the research. The first is about a case study point of view, which limits the possibility to conclude something generally accepted. Consequently, our results must be only hypothesis for future researches. In addition, our factor analysis is an exploratory trial. More data can help to define more clearly our bi-dimensional model and some specific study can aid to differentiate our dimensions accurately, for example defining the four possible quadrants in terms of techniques, their applications and relations.

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Mathematical Creative Thinking: An analysis of the importance of its implementation in the formative course of the student of the 21st century.

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Abstract

Themes such as “creativity” and “criticality” have been increasingly extolled when discussing the skills and competences essential in the process of training students to meet the challenges of the 21st century, justifying the need to prepare and encourage the new generations to make decisions from the analysis of different variables, surpassing the school practices restricted to the application (replication) knowledge formally taught in the classroom. To that end, several countries have been engaged in proposing tasks to stimulate critical and creative thinking. The objective of this work is to problematize how the students of the last year of Brazilian basic education, that are able to start to work and / or to continue their training course in higher education, solve a non routine problem in the field of mathematics, that means, how they solve a situation that requires creative thinking. Therefore, a qualitative analysis of some solutions proposed by students of the last year of high school, from a public school in the administrative region of Gama, Brasília - Federal District, to a problem extracted from the Creative Performance Test in the Field of Mathematics by Fonseca (2015), whose purpose is to evaluate traces of creativity in mathematics. The results suggest that students are not accustomed to solving problems that require decision-making in situations other than school routine, as well as, evidences that many do not even have the skills that allow them to reflect on the numerical sense. As a contribution, this paper presents some suggestions of possibilities of activities that favor the development of creative thinking in the field of mathematics, in order to better prepare the student for the demands of the 21st century.
Keywords: Creative thinking; Critical thinking; Mathematical creativity.

1 Introduction

Studies have shown recently that creativity is one of the most important competences that should be developed with an education perspective for 21st century (P21, 2016). After all, through this competence a person has a stimulation not to think in a traditional way, under different perspectives and points of view about the same problem, which is popularly called "thinking outside the box". In the field of mathematics, specifically, this competence helps the person to realize and resolve the problems that the world show him/her (Kanhai & Singh, 2017; Mann, 2005). The literature has shown that creativity is an ability that needs to be valued and its incentive must consider: (a) mathematical content (proficiency); (b) the way students understand the ideas (motivation); (c) how to prepare the students to the XXI century problems.

Mathematics is not imitated but it is a dynamic science that has been developing and its evolution contributes to a scientific and technological development and it also resolves problems around the globe. Mann (2005) confirms that a good mathematical mind is always ready to think in a flexible way and it also observes a problem in different possibilities by showing critical and creative abilities. This author also confirms that is pretty hard to stimulate creativity in the Mathematics field from activities that only presents algorithmic procedures when the better form of doing it is by showing them heuristic procedures (Mann, 2005), which is ratified by Grégoire (2016), that stresses to the fact that creativity in Mathematics has not been stimulate in classrooms. Therefore, this work has purposes: (a) promoting an analysis on how to improve the capacity of being creative through pedagogical practices for the present century, especially when it is connected to creative thinking; and (b) presenting analysis concerning the writing of the students who are in the last year of basic education focused on solving problems that require the elaboration of many solutions. It is also important to highlight that this work is based on Gontijo's definition of creativity in Mathematics (2006, p. 49):

> the capacity of presenting different possibilities of appropriate solutions to a problem in a way that distincts problems are focused and also various forms of resolving it in uncommon (original) forms, and when doing it, the individual might explore Mathematics elements and its functions and properties. It can be done by numbers, graphics and many actions.

2 Material e Methods

A performance test in the field of mathematics (TDCCM) by Fonseca (2015) was used in this research which was produced to measure latent traits of creative thinking such as fluency, flexibility and originality. These tests present versions A and B, which hold isomorphism in terms of difficulty and structure itself and also allows to be used in combination (pre and post test) or it can be done isolated across studies where the application is necessary only once. Both versions are composed by 5 open problems and the students should present as much solutions as many as possible, all done in a given period (5 minutes to itens 2,3 and 5 to 10 minutes to itens 1 and 4). It is emphasized that everything is done in the presence of the applicator who gives orders and controls the time to each item. Thus, the students do not preview the items.

The correction of TDCCM produces a score from the three latent traits of creative thinking: fluency, flexibility and originality. Fluency is measured from the number of ideas, strategies and solutions by the respondent while flexibility is about how many ideas the categories present. By the end, the originality is related to the production of the ideas, strategies and infrequent solutions when compared to the group of respondents to which the test was submitted at the same chance (Fonseca, 2015; Fonseca, Gontijo & Souza, 2015; Gontijo, 2007).

A high point about TDCMM is that it follows 3 validations : a) judges analysis; b) semantic validation with the target audience, and c) internal consistency analysis using the Cronbach coefficient. The last element of validation has obtained a= 0,784 to the version A of TDCMM and a= 0,771 to the version B. For research purposes, it has chosen to work with written solutions just on item 2 version A of the instrument, like this, the quantity analysis might be more detailed. It is the following item:

Table 1: Item 2, Version A, TDCCM

Andrew and Barbara work selling newspaper subscriptions. Andrew receives a permanent salary of R$ 750,00 plus a sales commission of R$ 2,50 for each sold subscription. Barbara, on the other hand, receives a permanent salary of R$ 1.000,00 plus a sales commission of R$ 0,50 for each sold subscription. Make up as many as Mathematical problems possible from this information.

Source: TDCCM (FONSECA, 2015)

To answer this item the students have had 5 minutes to create the problems. Some examples of these creations:

Table 2: Examples of Mathematical problems elaborated by the students

How much will they receive?
How much sales commission might Andrew receive if he sells 50 subscriptions in a month?
How many subscriptions Andrew should sell to achieve at least R$ 900,00?
How many subscriptions must be sold to each one have the same salary?

Source: Researcher's personal file

Considering the fact that the answers were respondent's production, there is:

a) Fluency: score of 4 (4 valid answers).

b) Flexibility: score of 31, from the following rule: 10 points referring to the first appropriate solution; 10 different group solution points; and 1 point by a similar solution but with the same distinction. The solutions have been classified as designative, conditional, designative and relational. Ready 10 + 10 + 1 + 10 = 31.

* The problems classified as designative were the ones that have presented a direct questioning and with no comparisons between the characters: 'Relational' relational were those that relate the characters who are in the context of the item and comparisons between them; Conditional were the problems that involved insertion of a condition next to the questioning.

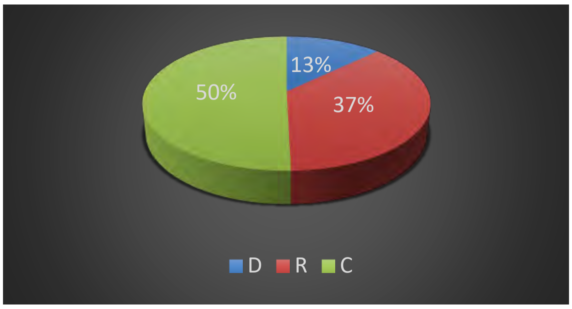
c) By originality: the score depends on the group rating, since from the occurrence of response in less than 15% of the cases it is worth 10 points, between 15 and 40%, 1 point, and above 40%, 0.1 points.

It is essential to remember that the public answered to this item was made by 108 students in their last high school year (last year of basic education in Brazil) enrolled in two different public schools in the outskirts of Brasília, Federal District. The collection of data was carried out during the first half of 2015.

3 Results

Through the result by applying the test, 258 problems have been captured, which means passable to solutions that are adequate and distributed in the three different categorizations highlighted above, such as Designative (d), Relational (R) and Conditional (C). The distribution is shown below:

Picture 1 – Categorization of written production of item 2 of TDCCM



Source: Prepared by researchers

In general, the problems seen as designative were limited to proposing questions related to variables, characters and other datas of the initial context of the item in a small number of framed productions in the category. Relational and conditional categorizations together present a number above 80% of written productions. In these categories, problems propose to compare the characters salaries and make them commom as in the following relational examples:

Table 3: Mathematical problems produced the by respondents - Relational

What is the difference between Andrew's and Barbara's salary?
How many subscriptions does Andrew need to sell to achieve Barbara's salary?
Considering the fact they do not sell many subscriptions a month, who receives more money?

Source: Researcher's personal file

All these solutions show the students could reflect on the situation out of the box, so they have elaborated some questions involving different forms of identification of the problem and about who makes more money during work. Certainly it shows how critical they were during the process and still a creative perspective around the situation, because they did not limit only to datas presented in the beginning of the process. Other solutions next:

Table 4: Mathematical problems produced the by respondents - Conditional

If both characters sell 100 subscriptions per month, how much is their annual income?
How much commission money will Andrew have in a month if he sells 50 subscriptions 3 days each?
By the end of the month Barbara received R$ 1150,00 bucks and Andrw R$ 835,00, how many subscriptions they have?

Source: Researcher's personal file

The mentioned questions bring another elaboration strategy of questionings by the respondents which is the simulation situations from the presented context. In that same way, they should suggest directions or complementary variables according to the illustrated content to wonder about a consequential projection of the situation by reflecting creative thinking which, one more time, shows how critical and creative they were while producing the questions and also understood better the scenerio.

In terms of punctuation, the originality scores to the designative questionings, relational and conditionals were respectively 10, 1 and 0,1 due to the percentage relative to the frequency of such categorizations in the list of respondent productions of the test. As follows, in terms of creativity, those with design solutions were more original, perhaps because it demands more time and organization of different ideas more than what the exercise has proposed, which involves more dedication. It is relevant to cite the students were at the end of basic education and they might be part of the integrate the labor market next year.

Although many of the problems are related to the future simulation, it is important to consider that each student could propose many solutions in different perspectives during a 5 minutes time. Thus, 1 student could think about 10 different problems while others did nothing, which means the ones who did not think in a critical way need motivation. The results, in terms of score, will be presented below:

Table 5: Descriptive statistics relating to item 2, version A of TDCCM

Average	**Mode**	**1º Quartile**	**Median**	**3º Quartile**	**S. Desvian**	**Minimum**	**Maximum**
66,084	0	2,2	22	48,4	121,673	0	610

Source: Prepared by researchers

Despite the variability from 0 to 610 points, it is necessary to consider that only 25% achieve the score over 48,4 - that shows most of the respondents did not produce critical and creative ideas to the situations. It shows how they need to be stimulated to develop such abilities, just like Mann (2005) confirms. Grégoire (2016) defines that the stimulations the students need demands implementations with pedagogical practices in the classroom by organizing learning activities outside the classroom.

4 Considerations

According to what is seen as a good education to the XXI century, the stimulation of creative skills must be present in schools, because from this competence the students will be ready to situations where they need to make fast decisions in all the areas, including Mathematics (Kanhai & Singh, 2017; Mann, 2005). It is important to highlight there are indications the creativity in Mathematics is related to motivation and proficiency in Mathematics as well

This research shows how students from the basic education show estrangement with open problems, in other words, out of school environment. Although they have shown creativity by elaborating problems just the last quartile has shown a considerably high grade which shows they had difficulty understanding the items but also in how to resolve them with elements most of them have used. In addition, the production of certain categories of response far superior to another may demonstrate preference or insecurity in elaborating problems based on data provided.

From this research it is concluded that more researches must be done focusing on how to stimulate creative thinking in Mathematics, establishing relations between creative and critical thinking and also aspects related to the correlation of creativity in mathematics with motivation and proficiency in the field. All those aspects must be discussed in the Brazilian territory. The conception of a dynamic math, which is a result of an interaction between people and world, is necessary to change the pedagogical practices in teaching field, specially in terms of Math. It needs to be changed so the students can see Mathematics as a dynamic key to different interpretations to other daily problems such as personal and academic-professional.

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A review of Problem/Project-based learning approach in engineering education: motivations, results and gaps to overcome

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Abstract

This paper presents a study of the use of the Problem/Project-Based Learning (PBL) in engineering courses. It covers publications in the area in the past 16 years, when the first motivations to use the aforementioned approach emerged. A qualitative analysis was elaborated in order to identify the relations and gaps in teaching-learning processes related to such courses. Among the obtained results, characteristics that are intended to be developed in engineering students through active learning were highlighted, as well as the motivational aspects and results of the use of the PBL methodology.

Keywords: Problem-Based Learning; Project-Based Learning; Active Learning; Engineering education.

1 Introduction

The Problem/Project-Based Learning (PBL) has been the subject of many studies related to active learning and the amount of published papers and citations in the area present an increasing tendency (Reis, Barbalho, & Zanette, 2017). According to Soares, Leao, Carvalho and Costa (2014), teaching approaches based on PBL have been widely employed as a way to develop students' skills, through the practical application of academic concepts learned from real-world situations, throughout a university's program. The engineering courses have a practical feature and the PBL has been applied in order to ameliorate the apprenticeship results in that area.

This paper provides an analysis of the PBL approach usage in engineering courses in the last sixteen years. Its main objectives comprise the identification of the motivating factors that lead to the utilization of the methodology and the results achieved after its implementation. In this way, it is expected to better understand the needs of an active learning approach in engineering courses and observed learning gains. At last, the authors present identified gaps in the teaching-learning process in engineering programs.

In the possession of the data exposed in this article, the ones interested in studying or implementing the PBL approach obtain a general map of the reasons why this learning methodology is used worldwide, being able to relate its own objectives to previous studies. Furthermore, the users of PBL can identify eventual results and problems already described in the literature; this enables them to take initiatives to potentialize or prevent the occurrence of specific outcomes. All these situations can be analysed considering a specific engineering subject.

2 Analysis

The identification of the most relevant studies related to PBL is crucial to develop the analysis proposed in this paper. According to Borrego *et al.* (2014), searching in many databases guarantees that the relevant ones are located. Thus, the databases selected to perform the search of articles were the ISI Web of Science, Scopus and Science Direct. A search was performed using the terms 'Engineering Education' and 'Project-Based Learning or Problem-Based Learning' for the period that ranges from 2000 to 2016. From the results obtained, the authors extracted only articles published in journals, obtaining 624 papers in total, 460 unique records.

As a refinement technique, the articles were ranked in each database according to their average citations per year, in descending order. As result, 49 unique papers were considered for further analysis, which correspond to 50% of the cumulative average citations per year in all the databases. From these total, the authors only had access to 45 works, which were analysed in this article.

Table 1 presents a stratification of the studied papers according to the engineering subject and country. It is noticeable that the PBL publications in engineering education have great representativeness in the USA and also vary considerably in terms of engineering subjects. Furthermore, the 'Electrical Engineering' and the denominated 'Engineering' courses presented the largest quantity of studies. In the papers mentioning 'Engineering' course, engineering is studied in a broad manner in the beginning of the courses, and the specific subject is defined after some semesters/years. It is also important to mention that some articles comprise studies approaching more than one country and more than one engineering subject; for that reason, the total number of courses identified in Table 1 is higher than the number of articles analysed.

Table 14. Number of studies per engineering subject and country

	Aerospace	Chemical	Civil	Computer	Electrical	Electronic	Engineering	Environmental	Industrial	Mechanical	Mechatronics	Telecommunications	Others*	Total
USA	-	1	1	2	2	-	5	1	-	-	-	-	1	13
Spain	1	-	-	1	3	2	-	-	-	-	1	2	1	11
Australia	-	3	1	-	1	-	2	-	-	-	-	-	-	7
Portugal	-	1	-	1	-	1	2	-	1	-	-	-	-	6
Germany	-	-	-	-	1	-	-	-	-	-	2	-	-	3
China	-	-	1	-	-	-	-	-	-	-	1	-	-	2
Finland	-	-	-	-	1	-	-	-	-	-	-	1	-	2
India	-	-	-	-	-	1	-	-	-	-	-	1	-	2
Belgium	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Brazil	-	-	-	-	-	-	-	-	-	-	1	-	-	1
Israel	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Mexico	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Norway	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Taiwan	-	-	-	-	-	-	1	-	-	-	-	-	-	1
United Kingdom	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Total	1	5	3	5	8	5	12	1	1	1	5	4	2	53

*Courses with minor representativeness in the research performed

In this context, it was performed a study of the results of each paper and the respective motivation factors to the use of the PBL approach, considering the following categories of engineering courses: Civil and Environmental Engineering; Chemical Engineering; Electrical, Electronic, Telecommunications and Computer Engineering; Aerospace, Industrial, Mechanical and Mechatronics Engineering, and; Engineering. The analysis performed follows in the next subsections.

2.1 Civil and Environmental Engineering

The articles in this category were about applications in undergraduate programs and were mostly present in the USA. The main motivational aspects that lead to the adoption of the PBL approach were the need to propose challenges with open-ended problems, requiring greater application of multiple engineering concepts (Chinowsky, Brown, Szajnman, & Realph, 2006), and the necessity to develop skills that are demanded by enterprises (Jollands, Jolly, & Molyneaux, 2012).

Some studies were conducted to determine the technical and personal abilities required of engineers and managers by today's construction industry. According to Jollands *et al.* (2012), some skills that graduates need to have and that can be induced by the use of the PBL are communication, teamwork, innovative thinking, critical thinking, creativity and design capability, which are not developed by the traditional education systems.

As a result of the application of the PBL methodology, Jollands *et al.* (2012) support the fact that the interaction with outside experts from the construction industry and related professions is improved. In fact, the introduction of this active approach in civil engineering curriculum provides two primary advantages: educators have the opportunity to expand beyond a knowledge point concentration and students have the opportunity to explore problems that encourage skills beyond traditional analytic intelligence, as project management skills, time management and confidence. In general, it can be said that positive impacts with the application of PBL were observed (Chau, 2007; Chinowsky *et al.*, 2006; Jollands *et al.*, 2012).

2.2 Chemical Engineering

The articles related to this topic focused on undergraduate programs and were developed mostly in Australia. The necessity of the acquisition of some transverse competencies by the students was the main argument to justify the use of PBL in the papers analysed. Among these abilities it is possible to mention personal and professional skills and attributes, such as interpersonal skills and the aptitude to conceive, design, implement and operate systems in the enterprise and societal context (Crosthwaite, Cameron, Lant, & Litster, 2006; Gomes *et al.*, 2006; Ragusa, & Lee, 2012).

The chemical engineering course of the University of Queensland is an example of achievement of good results with the application of active learning. In fact, it received innovation prizes about teaching in Australia and their students were awarded in students' national competitions (Crosthwaite *et al.*, 2006).

The study performed in the University of Sydney showed that its engineering program enhances students' motivation and their focus on self-directed learning, while allowing flexible learning. There was also a significant increase in student engagement with the broader learning process. Despite the 'raising of the bar' and the multiple challenges facing the enterprises, the percentage of students progressing from second to third year was about 85% during 2005, which was most encouraging. An important side-effect of adopting the new curriculum with an active learning has been 'team teaching' - each course being taught by several staff members -, which was a departure from their past practice. The extensive employment of the PBL approach with a staff coordinator for each course, for each semester and for each year encouraged staff to adopt a consistent team-based and student-centred approach. This has opened new doors for collaboration and for experimentation with teaching and learning options (Gomes *et al.*, 2006).

2.3 Electrical, Electronic, Telecommunications and Computer Engineering

The studies containing such engineering fields involve both undergraduate and graduate levels. The countries where they were mostly found are Spain and the USA. The need of the students in having practical experience, as well as being capable of dealing with technological challenges, industry problems and projects are some of the reasons to use the active learning approach (Bellmunt, Miracle, Arellano, Sumper, & Andreu, 2006; Macías-Guarasa, Montero, San-Segundo, Araujo, & Nieto-Taladriz, 2006).

The PBL was adopted in some studies aiming at enhancing students' depth and breadth of knowledge, initiative, teamwork, communication, commitment, autonomy, initiative, professionalism, sense of community, ability to troubleshoot and innovation aptitude (Costa, Honkala, & Lehtovuorii, 2007; Hosseinzadeh, & Hesamzadeh, 2012; Macías, 2012; Martinez-Mones *et al.*, 2005). In general, the emphasis was on the need for engineers who can perform professionally both in terms of technical aspects and generic engineering skills (Hosseinzadeh, & Hesamzadeh, 2012). Interestingly, some authors were encouraged by the success of PBL in engineering courses around the world and decided to implement this methodology (Mantri, Dutt, Gupta, & Chitkara, 2008).

There are positive results on the use of the PBL approach in the students' development (Macías, 2012). Relevant gains regarding the use of PBL were reported by Macías-Guarasa *et al.* (2006), namely: the increase in interest and in affinity with electronics, improvement of academic results, knowledge acquisition and more advanced skills to develop more sophisticated and realistic electronic systems. Martinez-Mones *et al.* (2005), Hosseinzadeh and Hesamzadeh (2012), Mantri *et al.* (2008) and Behrens *et al.* (2010) identified the development and increase of performance in students' communication skills, creativity, teamwork, practical ability, project management, team management, communication work and report writing. In some cases, the high level of motivation exceeded the professors' expectations.

It was reported that some students found the active learning approach courses interesting and challenging, in which their learning exceeded their expectancy (Bellmunt *et al.*, 2006). In fact, the PBL learning experience is considered very positive compared to the traditional methods (Costa, Honkala, & Lehtovuori, 2007), allowing the students even to obtain greater grades (Costa, 2007; Montero, & González, 2009).

Nonetheless, a few problems in the implementation of the PBL were also reported by some authors. According to Santos-Martin, Alonso-Martinez, Carrasco and Arnaltes (2012) and Mitchell, Canavan and Smith (2010), the students considered that they had to dedicate too much time working in this approach. Some of them expressed lack of confidence in their ability to engage with the problems in a holistic sense and feelings of insecurity, mainly in the form of grade anxiety. Time management proved to be a major issue with students who were overloaded.

2.4 Aerospace, Industrial, Mechanical and Mechatronics Engineering

The papers which reported activities in these fields were from Spain, Portugal, Israel, Germany, China and Brazil. In the Mechanical Engineering and Mechatronics workgroups, it was presented an issue not yet addressed in other engineering subjects that is the need to provide a clear idea of the possible working fields in the respective areas (Frank, Lavy, & Elata, 2003). Exploring and developing a new method to teach engineering, as well as adapting to local industry needs, which seek after engineers with practical solution skills, were motivations reported by Wang, Yu, Wiedmann and Feng (2012) to utilize the PBL approach.

The results of implementing PBL in such fields indicate a positive increase in students' competences, especially those related to competition (Gomez-de-Gabriel, Mandow, Fernandez-Lozano, & Garcia-Cerezo, 2011). It was also observed an increase in the students' conceptual knowledge and in their abilities to transfer this knowhow to new situations (Pandy, Petrosino, Austin, & Barr, 2004). Nevertheless, some problems using PBL were pointed out, such as the difficulty of the lecturers in adapting their methodologies to the new teaching approach, insufficient time to develop courses, inadequate laboratory resources, lack of special tools available and very complex administrative procedures (Frank *et al.*, 2003; Wang *et al.*, 2012).

2.5 Engineering

When the general engineering topic is studied, cooperative and/or inductive learning are considered very important to improve students' apprenticeship. As reported by Huntzinger, Hutchins, Gierke and Sutherland (2007), the method that incorporates all these three learning processes is PBL. In such a context, the student is responsible for his own learning process, which is one of the main characteristics of the active learning and a motivation for its usage (Soares *et al.*, 2014).

The articles comprised in the 'Engineering' category highlight that the PBL allows to address realistic problems and to use design as the vehicle for learning. Additionally, project development by students is a common way of learning in primary and secondary schools in many countries; hence, it is a familiar method to many freshmen (Palmer, & Hall, 2011).

Some skills were mentioned as necessary to the development of students and as the reasons to use the PBL approach. Among these abilities, it is possible to mention problem solving and more interpersonal aspects of a career, the called soft skills, such as leadership, communication, socialization and teamwork (Chandrasekaran, Stojcevski, Littlefair, & Joordens, 2013; Kumar, & Hsiao, 2007; Yadav, Subedi, Lundenberg, & Bunting, 2011).

Among the results identified in the publications, it is pointed out the students' higher motivation, the development of better communication and teamwork competences, a higher understanding of practical problems and better usage of the knowledge in these situations (Prince, & Felder, 2006). The PBL approach makes the student to take responsibility for their learning, ensuring deep and active involvement (Ditcher, 2001). In general, the perspective of engineering students is that the professional knowledge is useful for their careers, allowing the improvement of their lives and of the society (Tseng, Chang, Lou, & Chen, 2013).

In some cases, students regarded PBL as an effective way to learn, and reported that 'learn by doing' encourages the development of teamwork. In fact, it was possible to notice an improvement of students' creativity and responsibility (Soares *et al.*, 2014). It is interesting to highlight that in one of the universities assessed, the Smith College, there was a significant effort to redesign its curriculum in terms of sustainability and pedagogy. This means that the PBL approach was an essential element of the program goals and that the active learning concept could be completely integrated in the curriculum (Huntzinger *et al.*, 2007).

Despite the positive results, some negative points were identified by the learners, such as the high time demands for project work and the need for an introduction to teamwork and engineering/design report writing (Palmer, & Hall, 2011). Additionally, albeit some students consider that they got lower returns in terms of grades when compared to the traditional courses, they achieved better results (Fernandes, Flores, & Lima, 2012).

3 Conclusions

A great part of the publications was placed in the 'Engineering' category, which was the focus in the USA. This occurs as the universities have general subjects in the beginning of the courses and, after some semesters/years, the student is directed for a specific engineering course, such as civil, mechanical, among others. Regarding the schooling level, most publications addressed undergraduate courses. The subjects that concentrate most of the articles are the ones related to electrical engineering.

The articles analysed clearly point out to the use of the PBL approach in engineering programs as a positive aspect in the improvement of the apprenticeship process. The development of transversal competencies, the application of concepts in practice and the experience with real problems/projects are considered key factors in the application of the active learning approaches, being also a requirement to the admission in the today's companies.

The competences developed by the students after the adoption of the problem/project approach are diverse. Among the most cited, it is possible to mention teamwork, leadership, project management, innovative attitude, communication skills and ability to solve problems. The authors also reported gains in the students' performance, engagement, motivation and grades.

Nevertheless, it was possible to identify some gaps, reported mainly by the students, such as the feeling of obtaining lower returns in terms of grades when compared to the amount of workload expended in the courses. This aspect may result in lack of confidence, lower engagement and motivation. To prevent this problem, professors in some universities are using self and peer evaluation to assess students' abilities and behaviour (Chau, 2007; De los Ríos-Carmenado, López, & García, 2015; Hersam, Luna, & Light, 2004; Hosseinzadeh, & Hesamzadeh, 2012; Mantri, *et al.*, 2008; Palmer, & Hall, 2011; Rodríguez *et al.*, 2015), trying to make the considered criteria clearer to students.

From the point of view of teachers, some gaps have been identified as: difficulties in adapting their methodologies to the new approach, demand for time to develop courses, inadequate laboratory resources, need for greater interaction between teachers and students, among others (Frank *et al.*, 2003; Wang *et al.*, 2012; Soares *et al.*, 2014; Rodríguez *et al.*, 2015).

In general, it was possible to notice that the use of the PBL approach has many positive aspects. However, some effort and research still need to be performed to overcome the aforementioned gaps.

In general, it was possible to note that the use of the PBL approach has many positive aspects, in the teaching-learning routine and in the development of transversal competences by students and greater integration among all involved in the process. However, some effort and research still need to be performed to overcome aforementioned gaps and to improve the active approach to be enjoyed as an important tool for improving education.

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Problem-based learning - a proposal for a university introduction course with sustainability and environment as a structural theme

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Abstract

During a student's process of academic formation, it is expected that the necessary autonomy is developed in order to find solutions for the problems and for research, indispensable tools for this student to act upon society's improvement. Nonetheless, at Universidade de Caxias do Sul (UCS), it is possible to observe an increase on the number of students who start the academic process with a serious limitation on these skills, resulting in a decrease on the learning throughout the course. Aiming at reducing this issue, the current article proposes a description of a project of first-term course whose objective is to encourage a behavioural culture on the part of the students in this context. Through this course, the student may step towards his/her process of academic formation, becoming able to use the tools and research resources that the university offers, such as the library, the online environment, support teaching groups, laboratories, as well as interact with other students, instructors and professionals, enabling the student to understand the full scope of the university, beyond the physical limits of a classroom. According to the institutional pedagogical project and the national policy of environmental education, this subject will rely on the Problem-Based learning methodology, presenting as its main integrative theme the environment and the concepts of sustainability. To develop interpersonal skills, students will work in teams aiming at either one of these options: a) producing a documentary which reports on positive environmental and social interventions in the Serra Gaúcha region in the South of Brazil; b) develop a prototype of an ecologically sustainable system prototype. In order to reach either objective, students will be guided by the instructors through multiple activities, such as the planning of the work, round table discussions, bibliographic research, interviews, normatization, among others, developing abilities such as autonomy, planning, research and teamwork. At the end, students are expected to have progressed on the flourishing of conceptual, procedural and behavioural skills, as well as problem-solving ones, leading to significant improvement on the remaining of the undergraduation process.

Keywords: Problem based Learning; Higher Education; Engineering Education; Autonomy; Environment; Sustainability.

1 Introduction

The Universidade de Caxias do Sul (UCS) is an institution of Higher Education created by the efforts of the local community, in 1967, characterized as a community university. It is located at the Rio Grande do Sul state, in the city of Caxias do Sul, and acts on several other towns in the state being regarded as the oldest university in the region of *Serra Gaúcha*. Throughout the years, UCS has been gaining strength and offering several courses that cater for the local community, as well as other states. For these reasons, UCS receives students with diversified sociocultural features, a fact that more than often reflects on the process of adaptation to the academic lifestyle. Furthermore, the difference between learning in high school and learning in higher education institutions, the later demanding a high level of responsibility and autonomy, is another factor that impacts on the students' adaptation.

Littlewood (1996) believes learners should be actively involved in their learning; and it can also be the teachers' role to help them, scaffolding their learning, to become more independent on their way, behavior and thought of his own process. The autonomous student can make choices and act according to their need, but this autonomy depends on *ability* and *willingness*. A person may have both, ability and willingness or have the first one but lack the second to do so.

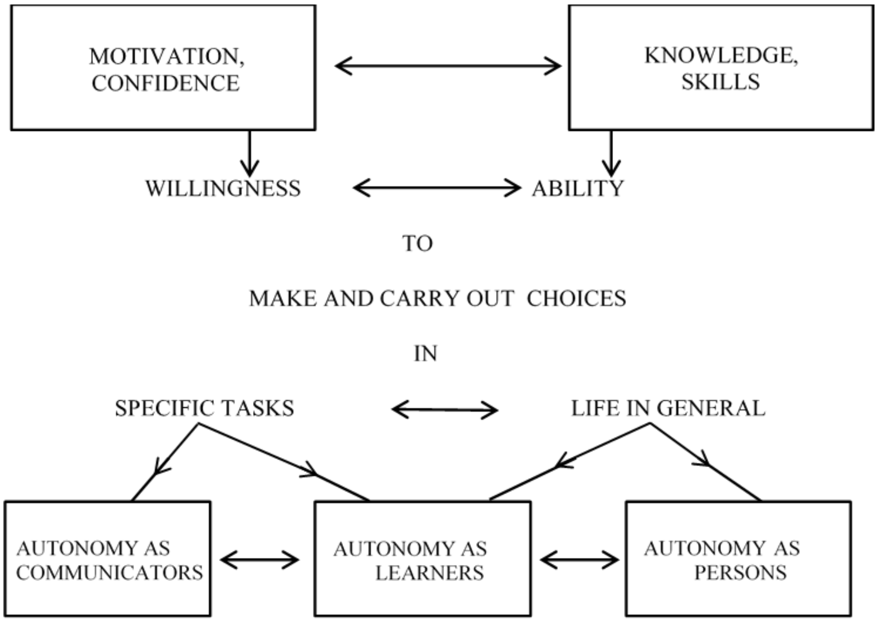
The opposite is also possible, a person may be willing to act, but does not have the ability to proceed. According to the author the ability is divided in *knowledge* (alternatives) *and skills* (ability to carry out). "If a person is to be successful in acting autonomously, all of these components need to be present together." (1996, p. 428)

When a learner can build the necessary knowledge and skills, he/she is likely to be more motivated and confident when executing tasks. The more confident he/she feels, the better he/she can access his knowledge and skills to perform autonomously.

In Figure 1, by Littlewood (1996), the diagram summarizes the main components and domains of autonomy, concerning second language learning, which we can also consider for any learning process.

"At the centre of the diagram are the basic components of autonomy (ability and willingness to make choices) and the two broad types of autonomy (task-specific and general)." (p. 430)

Figure 1. Components and domains of autonomy in foreign language learning. Source: LITTLEWOOD, 1996, p. 430.



Reflecting about the process and building the necessary abilities can be an important tool for the adjustment from high school to university and face the new obstacle.

This specific difficulty of adaptation to the academic life is an issue that has been researched throughout several universities, and is connected to the lack of autonomy on the students' part, on the psychosocial aspect as well as regarding aspects connected to learning and the resolution of academic tasks. Teixeira, Castro and Zoltowiski (2012) point to the influence of social and academic integration. Porto and Soares (2017) investigate the relation between the students' expectations and academic adaptation. Cunha and Carrilho (2005) analyse the relationship of academic experiences with academic performance. In Portugal, Almeida and Cruz (2010) state the difference between learning in high school and higher education. All of the previous aspects, no matter how much, interfere with the process of students' adaptation into academic life and cannot be ignored by educational institutions. Education institutions must, according to Porto and Soares (2017) "make available resources to provide the necessary positive experiences to the full educational development of the learners with the aim of achieving academic success among the university population".

Aiming at contributing to the student's academic adaptation, it is presented here a project of an introductory course, to be held at the beginning of the student's path, in order to introduce and provide base for the remaining courses which compose the curriculum of all the programs at UCS. This course load is 85 hours to be developed in 19 weeks. This course focuses on promoting academic environmental knowledge, research, teamwork, through the development of skills, decision-making and autonomy, and is structured on the pedagogical model known as Problem Based Learning (PBL), having as its themes the Environment and Sustainability. The PBL method, according to Viecelli et al. (2012), uses practical activities as a support for the investigation of possible solutions for real issues, even in the beginning of the course, providing an interdisciplinary learning enviroment and stimulating the insertion of the student into the academic community.

The themes *Environment* and *Sustainability* are interdisciplinary and comply with the demands of the National Environmental Educational Policy in Brazil (2017), which establishes that "environmental education must be present, in an articulated way, in every levels and modalities of the educational processes, formally or informally".

2 Teaching Methodology

2.1 Problem Based Learning Method

Problem Based Learning is a learning methodology that centres on the student and has as its base the solving of real problems, or simulated problems. So as to solve the problems, learners "make use of their previous knowledge, discuss, study, acquire and integrate knew knowledge. This integration, together with practical application, facilitates knowledge memorization, which can be more easily accessed, once the student faces new problems to solve." (BORGES et al 2014)

Regarding teamwork, PBL "creates a proper environment for the students to share responsibility, manage conflict situations, make decisions and cooperate on the team in order to reach an objective, through the appropriate management of time and students' exposure to alternative points of view" (BOOTH et al, 2016 p.43).

The choice of the problem is essential to the success of PBL, because it defines the contents which will be studied during the process. In the words of Ribeiro (2008), "a PBL problem may be an academic challenge, structured as to integrate a specific part of the course content, or a scenario, a real problem, however simulated, of the professional practice with the aim of integrating knowledge in an intra and interdisciplinary way. There is also the possibility of using real life problems, which may represent an effective way to gather the academic practice to the community; in other words, the functions of extended teaching of the universities."

2.2 Methodology of the course

The course will be offered at the beginning of the first term for students of all the programs at UCS, once the skills to be developed do not extend to one only area of formation; it will also rely on a team of instructors from the fields of Sociology, Languages and Environmental Engineering. The problem to be proposed to students will be one of the following: a) the production of a documentary reporting positive environmental interventions carried out at the Serra Gaúcha region; b) the development of a prototype of an ecologically sustainable system.

Students will work in teams of about 8-12 participants, with a tutor (an instructor) for each group, as well as a leader and a secretary, with each member of the team performing the role of leader or secretary in a rotational period of four weeks.

Along the course, students will use the virtual environment of the university (UCS Virtual) to interact with instructors and peers, clarify doubts and give suggestions. Besides, each group will be required to write a report regarding the activities carried out in each meeting, making it available on the virtual environment for the appreciation of the instructors, with the aim of developing skills in writing.

2.3 Objectives

The main objectives of the course are:

- Developing skills and competences on the use of academic resources and tools
- Developing teamwork skills

- Stimulate proactivity and the construction of autonomy on the student
- Encourage the student's self-awareness regarding the establishment of connections between his/her previous knowledge and new information
- Developing the awareness regarding environmental care, as well as strengthen social values such as ethics, moral and citizenship.

2.4 Schedule of the subject

The schedule of the subject, shown on table 1, is based on the structuring steps proposed by Booth et al (2016, p.46).

Table 15: Activity schedule

Week	Activity
1 and 2	Awareness: The instructor will introduce the course, its objectives and the structuring theme, i.e. sustainability and environment. Discussion with specialised guests.
3	Investigation: Field trip to identify social and environmental actions, aiming at eliciting possible problems related to the theme.
4	Identification of what students want to learn: Gathering of the teams. Definition of the subtheme that each group will work with. Development of the working plan.
5 and 6	Formative stage: The students will know the library's premises and functioning, the research systems and the data base. Introduction to the basic concepts of writing and formatting according to the Brazilian normatives.
7	Interaction with previous existing knowledge: The teams will start the research about the chosen subtheme, determining how the bibliography research will be carried out, taking into consideration different areas of expertise.
8 and 9	Comprehension of the process, the conceptual contents and identification of what has been learned: Deepening of the theory foundation.
10 and 11	Consolidation of what has been learned: Oral presentation of the theory foundation papers. Defining of new actions, according to the feedback provided by the instructors and the other teams. Peer evaluation.
12	Learning increase: The teams start the planning of the documentary or prototype.
13 and 14	Interaction with previous knowledge: Field trip to carry out the development and production of the documentary or prototype, based on the technical work previously presented.
15 and 16	Identification of what has been learned: Development of the documetary or prototype: systematization and data analysis.
18 and 19	Self-evaluation and peer evaluation: Presentation of the documentaries or prototypes

2.5 Assessment Process

The assessment of the course will depend on the activities carried out and will be organized as follows:

Reports presented on UCS Virtual – 30%

The assessment will be carried out by the instructors according to each report presented, allowing the follow-up of the development of each team's work, its advances and if necessary interventions to correct errors. This way, the assessment will have a continuous characteristic, following the student during all the learning process.

Written paper with theoretical framework – 20%

It will be required by the instructors in the middle of the term (weeks 10 and 11), with the evaluation criteria previously discussed with students. The results will be shared with the students, providing useful and constructive feedback, conferring meaning to the assessment process (PANÚNCIO-PINTO; TRONCON, 2014).

Presentation of the paper with theoretical framework (weeks 10 and 11):

Peer Evaluation – 10%

Self-Evaluation - 10%

Presentation of the documentaries or the prototypes (weeks 18 and 19):

Instructor Evaluation of the presentation – 10%

Peer Evaluation – 10%

Self-Evaluation - 10%

<u>Peer evaluation</u>

The process of peer evaluation may be understood as a mechanism of self-regulation of the learning process (BOOTH et al, 2016, p.52). In this course, students will evaluate the performance of their team partners. The evaluation criteria will be provided by the instructor. An example is shown on table 2.

Table 2: Peer evaluation criteria.

	Yes	No	Sometimes	How could it be improved?
Showed respect for the opinions of the peers				
Showed punctuality on the arrival and did not leave early				
Contributed with comments and suggestions				
Contributed to the gathering of information and carried out the work under his/her responsibility on the solution of the problem				
Handed in the tasks that were under his/her responsibility on the deadline that was established by the group				
In the general development of the work, contributed on the management of time				
Contributed to the good relationship between the members of the team.				
Considering a grade from 0 to 10, the peer deserves _________ Justify Other comments and suggestions				

Self-evaluation

On self-evaluation students will assess their own work, enabling "an analysis of the skills and competences acquired during the process and the ones yet to be developed, diagnosing mistakes and correct attitudes in order to contribute to the student's autonomy" (VIECELLI et al, 2012). The evaluation criteria will be provided by the instructor. An example is shown on table 3.

Table 3: Self-evaluation

	Yes	No	Sometimes	I can improve	I'm great

I showed respect for the opinions of the peers					
I showed punctuality on the arrival and did not leave early					
I contributed with comments and suggestions during the meetings.					
I contributed to the gathering of information and carried out the work under my responsibility on the solution of the problem					
In the general development of the work, contributed on the management of time					
I contributed to the good relationship between the members of the team.					
I sought help with the instructors when in doubt					
I learned the contents listed as structuring concepts by the instructors.					
Considering a grade from 0 to 10, I believe I deserve ________ Justify Other comments and suggestions					

These peer and self-evaluation forms will be applied in two moments as described above as a mechanism of self-regulation of the learning process and of the teamwork.

3 Conclusion

The proposed course can be considered easy to implement, since it is to be held on the first term of every program, not overlapping with any course already in operation at the Universidade de Caxias do Sul. It applies a method of active learning, which has been motivated and praised by the institution, due to its better results when compared to the tradition approach of teaching/learning, contributing to the development of the student’s autonomy and his/her adaptation in academic life.

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International student projects in a blended setting: How to facilitate problem based project work

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Abstract

This paper describes our experiences with facilitating international student projects during three years of the Erasmus+ Strategic Partnership COLIBRI (Collaboration and Innovation for Better, Personalized and IT-Supported Teaching). Each year 7-8 student projects were carried out in groups of 3-5 students from different European universities, with different backgrounds from business and engineering. Each year new students were selected for participation.

The student projects carried out were based on real-life problems from companies, and each group was assigned both an academic supervisor from one of the seven participating universities and an academic supervisor from one of the three participating companies.

The projects were based on a combination of physical mobility and virtual mobility: The students would meet for one week at the beginning of the project work, then work together virtually for around 2-3 months, and then meet again for a week where the projects were finalised and evaluated.

This setup is challenging: The students do not know each other beforehand, most of the students are not familiar with problem based projects and collaboration with industry, the students represent both different educational traditions and disciplines, and the virtual collaboration is by itself challenging.

The project was carried out in three cycles, where for each cycle we systematically evaluated the previous experience and adapted our approach to e.g. project descriptions, seminar organisations, elements to support the students in the project work, and project supervision. Based on our evaluations, we see that each year student satisfaction was increased, and at the same time both companies and students reported improved learning outcome and project results.

The last year a survey was made for the students to evaluate the support from different elements such as online modules, introduction to project work, instructions of expected outcome, templates, and supervision during both physical and virtual collaboration phases.

We conclude that such international and interdisciplinary projects can be very rewarding, but also that careful planning and implementation is needed to achieve the full potential.

Keywords: Problem Based Learning; Interdisciplinary; Internationalisation; Collaboration.

1 Introduction

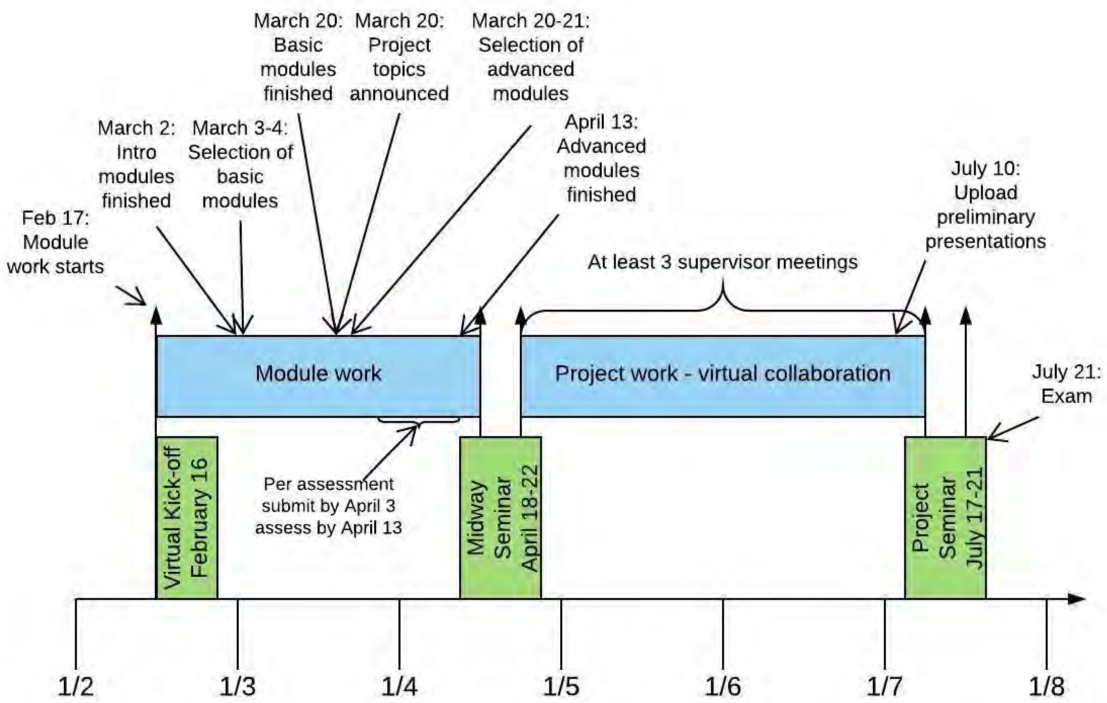
The COLIBRI project (Collaboration and Innovation for Better, Personalized and IT-Supported Teaching) (COLIBRI, 2017) was mainly motivated in order to solve three of the main challenges universities are facing today: (1) An increase in the number of students and with this also a more diversified student population which includes many more students who would not previously have chosen a university education, (2) an increasing pressure in order to ensure candidates are better prepared for the labour market upon graduation which requires not only technical skills (Walther et al., 2011), (Crawley et al., 2007), (Walther et al., 2007, and (3) the challenge of integrating new digital technologies in education and to find a position in a world where Massive Online Open Courses are becoming increasingly popular (Martin, 2012),.

The COLIBRI project has provided an experimental lab, where students from 7 different European universities followed a 5 ECTS course during the spring semester. The course, with the title "Future Internet Opportunities " has been running through three years (2015-2017), each year with around four students from each university, and each year adjusted to the experiences of the previous years. The students came with different backgrounds such as Engineering, Computer Science, Entrepreneurship and Business Informatics. Running throughout the semester, the course had the following main component:

- A virtual kick-off meeting with participation of all involved students and teachers.
- A phase of around 1.5 months, where students were working on course modules provided, mainly online.
- A midway seminar, where all students and teachers meet physically for 5 days to finish the course modules and start out the project work.
- A phase of around 2 months, where the students work on projects – virtual collaboration between international and multidisciplinary groups, based on real-world problems from companies.
- A project seminar of 5 days for all students and teachers, where the students can finish the projects. The exams are conducted as group exams with individual assessment (pass/fail) on the last day of the seminar.

Figure 1 gives an overview of how the course was conducted in 2017, the last year of the COLIBRI project.

Figure 23. Overview of the COLIBRI course in 2017.



A more elaborate description of the course and the results from previous year are discussed in (Pedersen et al., 2017). As also described there, the main conclusion after two years was that while the students appreciate most of the new and innovative teaching methods used throughout the course (including online modules, blended learning, and interdisciplinary projects), the student projects based on real-world problems, interdisciplinary, collaboration, and internationalisation has received strong evaluations, both in qualitative and quantitative parts of the evaluations. Previous research also shows that Problem Based Learning enhances the student's intrinsic motivation (Masek et al., 2016).

However, carrying out such student projects in a blended setting is also a challenging experience: The students come with very different backgrounds, including different understandings of what a project is and how it should be carried out, and the fact that most of the work is to be carried out over a distance further adds to the complexity. It should be mentioned here, that the student groups were designed with diversity in mind, so all 3-4 students come from different scientific backgrounds and different universities/countries. In this paper, we dig further into how the student projects were facilitated. In particular, we demonstrate how we increased the students' satisfaction with the virtual collaboration phase through better and more structured facilitation of the project work – an effort applied from the first virtual kick-off meeting and throughout the course to the final project seminar.

The paper is organised as follows. Section 1 gives an introduction to and motivation of the paper. In Section 2, we explain more about the student projects, and how they were integrated in the course. Section 3 provides an overview of how the project was supported and facilitated by us, as well as the student evaluations of the project after each year. For the final year, we also present results on how the different supporting elements provided support to the project work. Along with the descriptions we also discuss our experiences and observations. Section 4 provides a conclusion and discussion of further work.

2 The COLIBRI course and the project work

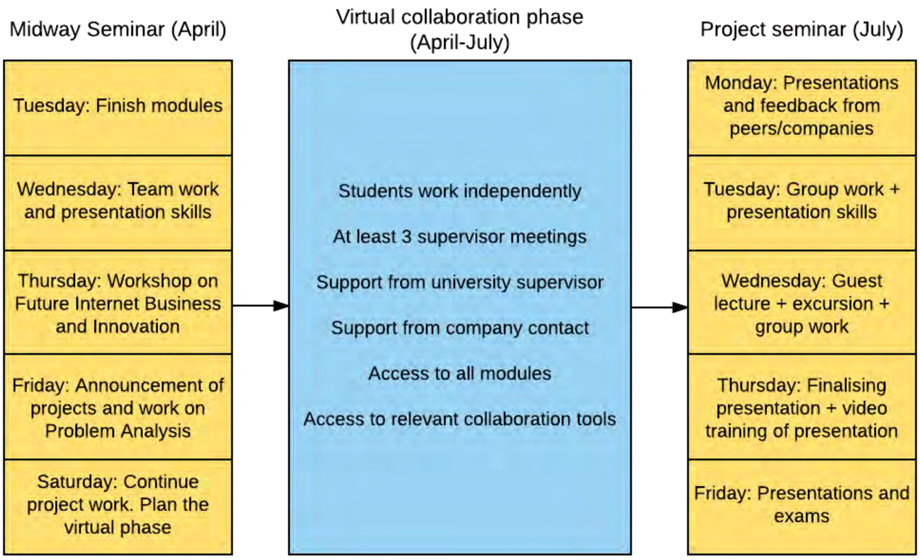
The two core parts of the COLIBRI course are the modules and the projects. The modules are organised as 10 different modules, where each can be followed as introductory, basic, and advanced levels. All students follow all the modules at the introductory level, while they have to choose a certain number at basic and advanced levels. The modules are supposed to support the project work by giving the students a good background for solving the challenges they will face in the projects. This requires that the content of the modules fits well with the problems the students work on during the project work, and therefore the content of the modules and the content of the projects needs to be coordinated.

In the COLIBRI course, this coordination effort was initiated well ahead of the course start, namely during a teacher training seminar that was held each year in October or November, prior to designing the modules. The coordination of project proposals and module content is one of the things we have been working to improve during the three years.

During the three years, we experimented also with other factors regarding how to start up the project work. For example, we experimented with when to form and announce the groups, how to ensure a good coverage of knowledge in each group, when to announce the project topics, and how to distribute the different projects among the groups. However, the group work really started during the midway seminar, as we wanted the students to be able to discuss the project face-to-face, and also to support them – both to ensure a good project start, and to avoid conflicts and disagreements that could be hard to resolve in a virtual-only setting.

The flow of the project work, including an overview of activities in the two seminars, are shown in Figure 2. The figure illustrates the flow during the last year of the project, but it was quite similar in year 1 and year 2.

Figure 24. Flow of the project work of the COLIBRI course in 2017.



3 Supporting and facilitating the project work

3.1 Year 1

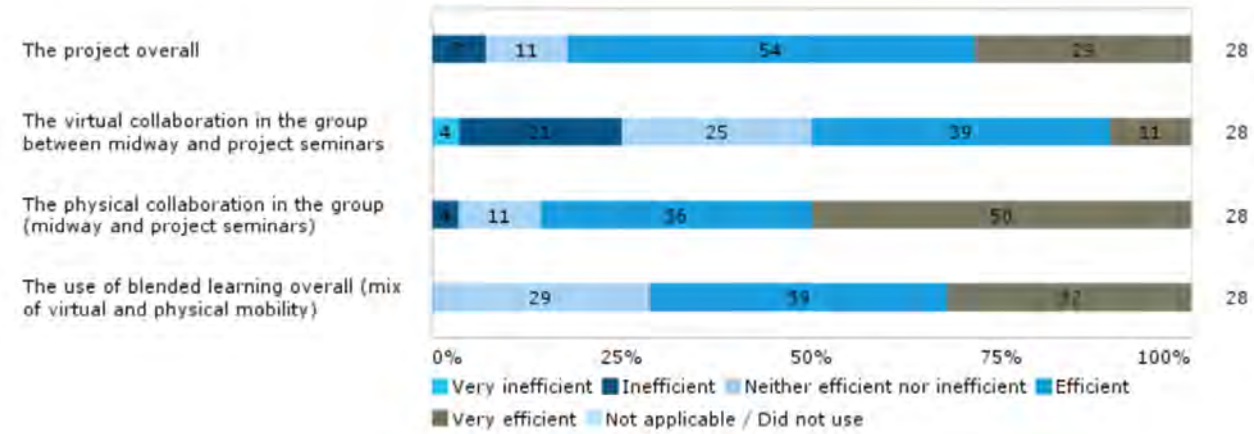
During the first year, the project was supported as follows:

- During the teacher training seminar in November, all project proposals were presented, and it was discussed how the proposals would fit with the modules provided.
- The students chose their basic and advanced modules independently, and were basically free to choose the modules they wanted. We checked that all modules were selected by at least one student, mainly to ensure that we could evaluate the form and content of each of the modules.
- The groups were announced on day 3 of the midway seminar. In this way, we wanted to be able to get the whole group of students to get to know each other before diving into teams, and we wanted them to be able to meet and discuss face-to-face instead of having the first meetings to be virtual. We did not want the students to create the teams themselves, as they do not really know each other at this stage, and in case of conflicts we would only have limited time and possibilities to resolve these.
- The projects were distributed randomly during day 4 of the midway seminar. The main reason for this was that we wanted to ensure that (1) there would be no conflicts in the groups if they did not agree, and (2) we wanted to make sure that all project proposals were selected.
- During the seminar, the first two days were dedicated to exercises for the students to get to know each other, and activities to round off the modules. This left us with three days related to project work. Day 3 of the seminar was dedicated to introduction to group work with case studies, role plays and exercises as well as announcement of groups. During the last two days, the students were working in groups on the project, supported by the supervisors. They were asked to create their initial problem analysis, as well as to plan their work until the project seminar in July.
- The students also got a short introduction to online collaboration tools, but were basically free to choose according to their own preferences.
- The students did not get any intermediate deadlines, but were asked to prepare a preliminary presentation for the project seminar, which should be submitted one week before the start of the seminar.

The students evaluated their outcome of the project work through a questionnaire distributed during the last day of the midway seminar. The course as a whole, as well as all the modules, were evaluated at the same time but in this paper, we focus on the results of the project work. The evaluations from year 1 are shown in Figures 3-4.

Figure 25. Students overall satisfaction with the project, year 1.

Figure 26. Students evaluation of learning effectiveness of different elements of the project, year 1.



We see that the students are generally happy about the project work, as 82% of the students rate their satisfaction as either good or very good. However, the numbers are a bit more mixed when it comes to evaluating the efficiency of the different elements. The physical collaboration between the seminars received a very good rating with 86% finding it either efficient or very efficient, whereas only 50% of the students found the virtual collaboration to be efficient or very efficient – something that probably contributed to the mixed scores of the overall evaluation of the blended mobility. The qualitative evaluations were generally positive as well, but some of the critical comments were dealing with (1) that some of the students found the projects to be unclear (or very open), (2) that it was in some cases hard to relate modules and projects, and (3) that it would have been an advantage to form the teams earlier.

3.2 Year 2

Based on the qualitative and quantitative evaluations from the previous years, it was decided to adjust the approach to project work in the second year. We especially wanted to increase the efficiency of the virtual collaboration part. Moreover, groups were formed earlier, and the students had to coordinate their choice of modules with each other – in this way, the students would already know each other a bit when meeting during the seminar.

During the second year, the project was supported as follows:

- During the teacher training seminar in November, a more elaborate discussion of fit between project proposals and modules were taken in order to ensure that all project proposals would fit with at least 3-4 of the modules provided. Moreover, each project proposal would contain a list of the most relevant modules (mainly as a help to ensure that the modules were taken into consideration when writing the project proposals, but also to be considered when forming the groups).
- This year, the groups were announced already during the virtual kick-off meeting, and "collaborative competition" was made, where students were competing in these teams in order to answer quiz questions – some related to the COLIBRI project, some related to the content of the modules. The purpose was that the students get to know each other a bit on beforehand, and also that they see how different team members can contribute with different knowledge.
- The choice of basic and advanced modules was done in collaboration between the groups: That is, each group would meet virtually and discuss their choice of basic modules within the group (and with

participation of the course coordinator) in order to ensure a broad coverage of the topics. Again, this dialogue would contribute to the students getting to know each other already before the seminar.

- The projects were distributed based on an attempt to fit student choices of modules with the most relevant modules of the projects.
- The programme for the midway seminar was updated compared to the first year. In particular, only one day was set aside for finishing the modules, and four days for focusing on the project work. Also, the team building exercises were done in the same groups that were already formed and which would do the projects together later.
- In the first year, company representatives only participated in the (final) project seminar. This year, they attended the seminar for a few days, where they could help the students to understand and narrow down the problems.
- During the second year, there was more focus on being precise about what was expected from the students at the end of the seminar. Each group was asked to present their preliminary problem analysis and plan for the virtual phase in front of the other students.
- To support the project work, templates were provided for project group meetings as well as for time plans.
- More focus was put on the role of supervision and supervisors: In particular, a short guideline for supervisors was made, and supervision was discussed among the supervisors during the midway seminar.
- The students got a more elaborate introduction to online collaboration tools, and each group was assigned particular tools to try out.
- As for the previous year, each group was asked to prepare a preliminary presentation for the project seminar, which should be submitted one week before the start of the seminar.

The evaluation results from the students are shown in Figures 5-6.

Figure 27. Students overall satisfaction with the project, year 2.

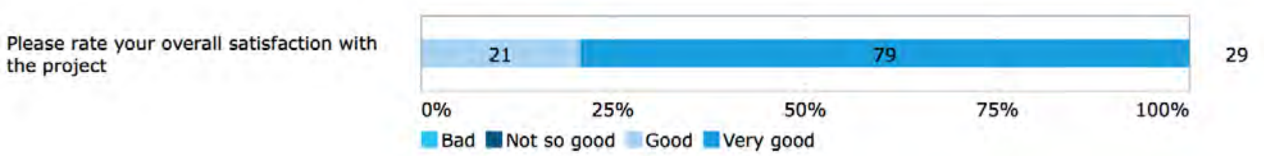
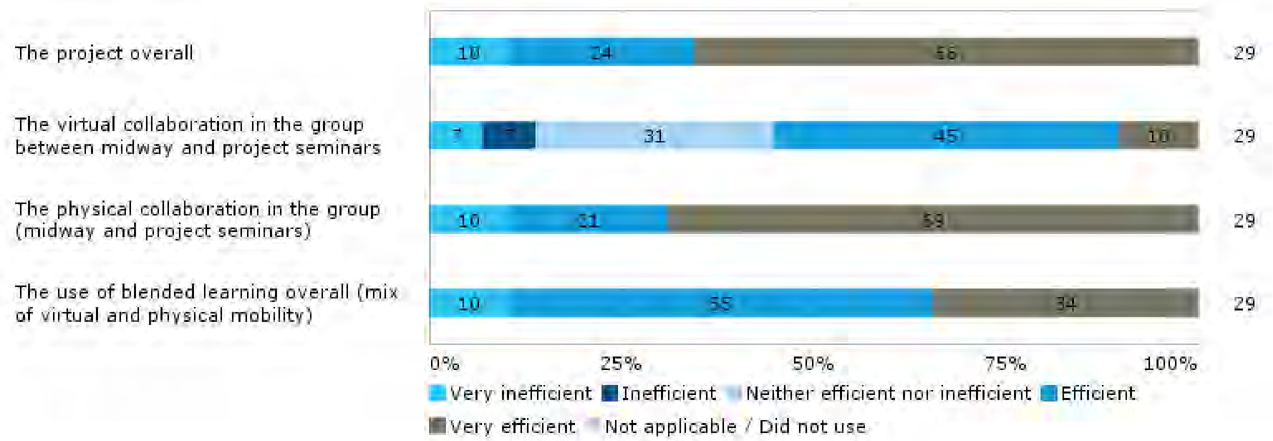


Figure 28. Students evaluation of learning effectiveness of different elements of the project, year 2.



It is first of all noticeable that the overall satisfaction with the project has increased significantly compared to the first year. This is reflected also in the evaluation of the effectiveness of the different components of the project, both overall and with respect to the physical collaboration in the groups during the seminars. However, the virtual collaboration is still the weakest link. This year, very few critical comments were given to the projects.

One student mentioned that more contact with the supervisor during the virtual phase would have improved it, and another student that the topics of the modules could fit better with the project proposals.

3.3 Year 3

Based on the results from the previous years, the ambition of the last year was again to improve the efficiency of the virtual collaboration phase. Based on the comments from the students and our experiences from teaching and supervision, it was decided this year to help the students structure the work during the virtual collaboration phase better. In the third year, the following changes were made:

- Again, the groups were made already during the kick-off, so the students got to know each other from the beginning. The groups were also made to collaborate on choosing basic and advanced modules.
- The projects distribution was announced already after finishing the basic modules, just before the students started to work on the advanced modules. This allowed for a better integration of modules and projects, since assignments in the advanced modules could relate to the specific projects students were working with (for example, an exercise could be to apply a specific methodology in the problem domain of the project).
- The structure of the midway seminar looked similar to that of the previous year (one day for the modules, four days for the project work), but each and every activity during the last four days were designed to support the students in getting (1) a good start on the project work, and (2) a good preparation for the virtual phase. The workshops on group work, collaboration, etc. were prioritized higher and done earlier in the programme, to allow for more time for the students to work together. For most activities during the week the students were asked to prepare work sheets or results that would help them during the virtual phase.
- We wanted to make sure that the students first of all achieved a good problem understanding. This was achieved through more supervision meetings (not only by requests from the students), by panel discussions where students were asked to prepare questions on their projects for teachers representing a broad spectrum of expertise, and by having all teachers and company representatives passing around in the groups and discussing different aspects of the problems.
- During the midway seminar, supervisors also exchanged knowledge and experience on how to give the groups a good start on the virtual phase.
- At the end of the midway seminar, the students had to prepare specific plans including meetings and milestones for the virtual phase. Supervisors also made a stronger effort to ensure that the plans were sufficiently substantial and specific.
- The students were provided with templates to be used for task descriptions, meeting minutes and time plans.
- During the virtual phase, it was required that each group should submit a short status report to their supervisors every second week. This requirement was introduced along with the other project requirements, and announced during the midway seminar.
- All in all, we provided a much more structured approach to the students, while still ensuring the projects to be student driven.

Figures 7-8 presents the results of the student evaluations.

Figure 29. Students overall satisfaction with the project, year 3.

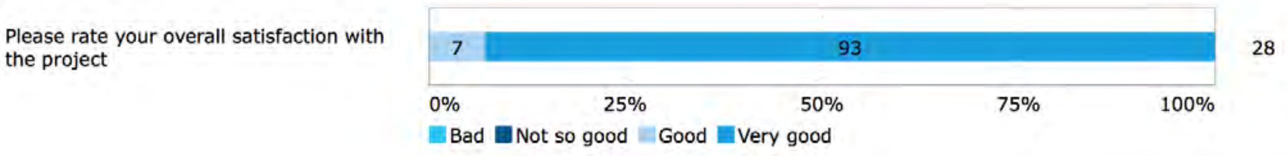
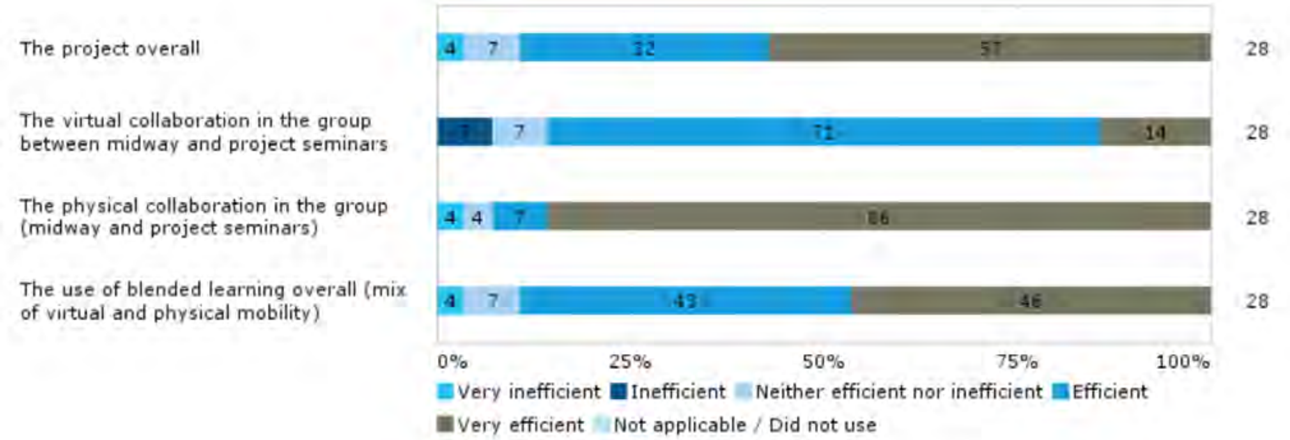
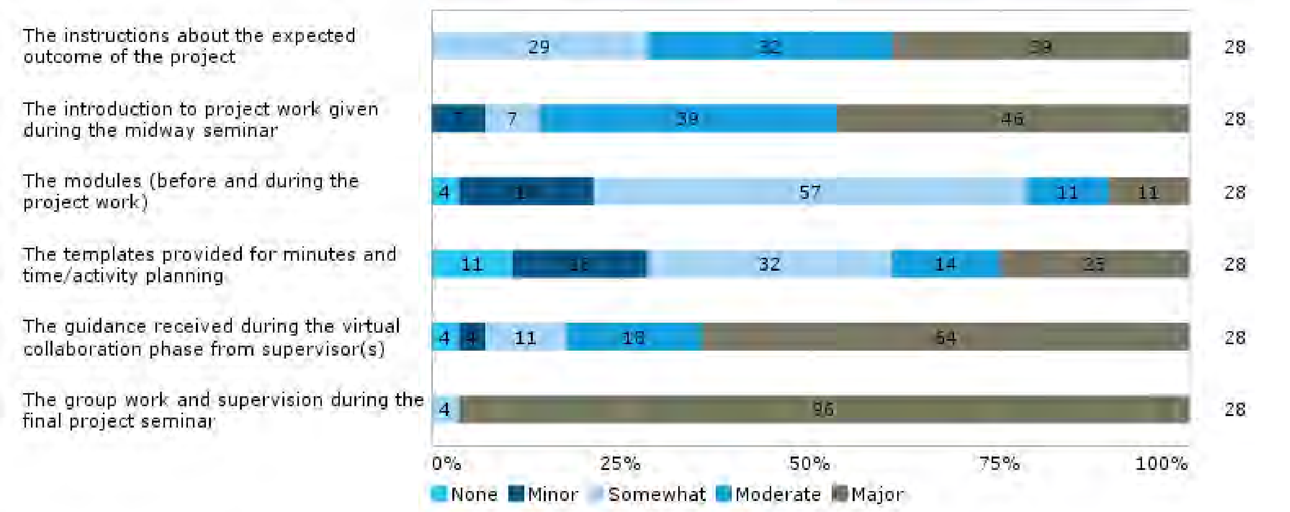


Figure 30. Students evaluation of learning effectiveness of different elements of the project, year 3.



Again, the student satisfaction has increased compared to the previous years. 26 out of 28 students rated the project as "very good" and the remaining two students as "good". Looking into the specific elements of the course, we see a general increase in satisfaction of both the projects overall, the physical collaboration in the groups during the seminars, and the use of blended learning overall., This year we also succeeded in raising the effectiveness of the virtual collaboration in the groups: 14% found it to be very efficient and 71% to be efficient. So, in total 85% found it efficient or very efficient, compared to 50%-55% in the previous years. To get a deeper understanding of which elements contributed the most to the project work, an additional survey was made in the last year, see Figure 9.

Figure 31. Students evaluation of learning effectiveness of different elements of the project, year 3.



The results of the survey indicate some interesting findings. While it is clear that the project work and supervision during the final project seminar receives a very high score, and that the modules seem to play a lesser role, the rest of the elements are a mixed bunch. The templates provided were not used by all students, but it appears that those using them found them to be very useful and supportive. Otherwise, we believe the survey demonstrates that supporting the project work in a blended setting as the COLIBRI course really requires all phases to be thought through: From the project proposal definitions to the group formation and project distribution, to the soft and hard parts of supporting the project work from the beginning to the end.

4 Conclusion

Conducting international and interdisciplinary student projects based on real world problems can be a very valuable learning experience for students. Doing so in a setting of blended learning has many advantages: For example, it does not require a full semester abroad, and it can be integrated to the normal schedule of students. Moreover, it is possible to establish truly international and interdisciplinary environments by bringing together students from different countries and study areas who would not normally be studying together.

Throughout the three years of the COLIBRI project the students have been very satisfied with the project work, but we found that especially the blended setting and use of virtual mobility gave some challenges. Throughout the three years we adjusted our approach, and eventually improved the evaluation of both the project as a whole and the different components – including the virtual mobility component. The results demonstrate that if properly and carefully supported and facilitated, this kind of project work can work out well even in a blended learning setting mainly based on virtual collaboration. However, we would still stress that we found the physical collaboration seminars to be crucial for the following virtual mobility to work well.

While our project was carried out in a blended setting, we think many of the experiences and conclusions also hold in a setting without the virtual component, including semester projects and thesis projects. However, the challenges become more outspoken during the virtual components where it is harder to clarify uncertainties than when everyone is located in the same place.

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Insper's Approach to Embedded Computing Discipline

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Abstract

With no consensus on the method for teaching microcontrollers and embedded systems, different approaches are used by universities all over the world. This article aims to describe and present the rationales for the approach taken at the Embedded Computing course of the Insper Computer Engineering program. Our approach deals with embedded systems in a broad though contextualized way, while paying attention to technical topics.

The main objective of the course is to enable the students to design and develop embedded computing systems, with a focus on software optimization for microcontrollers and their interfaces. The course has two main concurrent activities: The first is the development of a project proposed by the students involving embedded computing and that should have contextualized application, simulating the creation of a new product. The second one deals with technical subjects, approaching programming techniques and embedded systems design, helping the students in the development of a term project. The two major activities are performed at all weeks with classes alternating between them.

Projects are carried out in groups. The topics for those are selected by means of a group dynamic that eliminates ideas that are not widely accepted by all students. Once the topic is defined, student have to follow a sequence of activities whose objective is to guide the groups to a good specification of solution. Such activities have a strong focus on specification and diagramming of solutions through ideation, block diagrams and documentation. The technical concepts that are required to master embedded systems techniques are studied through small programming challenges and handouts that aim to foster autonomy.

We tried a new approach for evaluating the progress of the individual students in the course, in which they were able to monitor their performance in each of the main learning objectives, in order to understand their evolution throughout the semester.

Keywords: Active Learning; Engineering Education; Embedded Systems.

1 Introduction

Mastering the programming and specification of embedded systems is essential for the design of virtually any up-to-date electronic device. Current concepts such as: The Internet o Things (IoT), Smart Grid, stand-alone systems, among others, make extensive use of embedded computing to make their projects viable (Wolf et al., 2000; Suciu et al., 2013).

An increasing share of new consumer and industrial products demand embedded system skills to be created, making it a relevant field for computer engineers in the job market. This demand is also explicitly stated by the brazilian Ministry of Education (MEC) in the national curricular guidelines (MEC, 2016) for computer engineering (translated from portuguese):

> *The Computer Engineer is a professional with a generalist training, that works in industrial informatics, industrial networks, information systems applied to engineering, computer systemas and embedded computing. (...) On top of those skills, the computer engineer designs, develops and builds computational devices, peripherals and systems that integrate hardware and software.*

The computer engineering guidelines underscore on several opportunities the importance of embedded systems, the use of microcontrollers interfacing computer programs with the real world and the interface between hardware and software.

Embedded systems designs are usually tied to other large areas of knowledge (Markell and Grabau, 1998), and require interdisciplinary skills to understand the problem and propose solutions. Medical, automotive, entertainment and military sectors are examples of major users of this technology.

Every Insper engineering major has to take two first-year courses (Measuring and Instrumentation and Electrical drives) that use microcontrollers on a basic level. This first contact is based on Arduino, but focuses on prototyping and getting the projects done interfacing with basic sensors and actuators without necessarily using advanced microcontrollers techniques (for high performance, low overhead and low power, for instance). The Embedded Computing class is in the 5th semester of computer engineering and has the objective of looking into details of digital electronic systems that previously were seen by students as black boxes. The course aims to give the students familiarity with the particulars and design trade-offs involved in interfacing microcontrollers with peripherals and optimizing software for them.

At the end of the course the students should be able to:

- Create software for microcontrollers using their specifics (peripherals / low power);
- Evaluate and improve embedded solutions integrating hardware / software taking into account suitability to an application;
- Integrate into a prototype hardware, basic software, real-time operating system and user interface, communication and power modules;
- Understand the limitations of microcontrollers and their peripherals;
- Be able to search and analyse datasheets and extract relevant information.

2 The course

The course has two main concurrent activities: The first is the development of a project proposed by the students involving embedded computing and that should have contextualized application, simulating the creation of a new product. The second one deals with technical subjects, approaching programming techniques and embedded systems design, helping the students in the development of a term project. The two major activities are performed at all weeks with classes alternating between them (two classes per week), to a total of 30 lessons. The total estimated student time load is: 60 hours class, 45 hours of attendance and 60 extra hours room totaling 169 hours of dedication to the course.

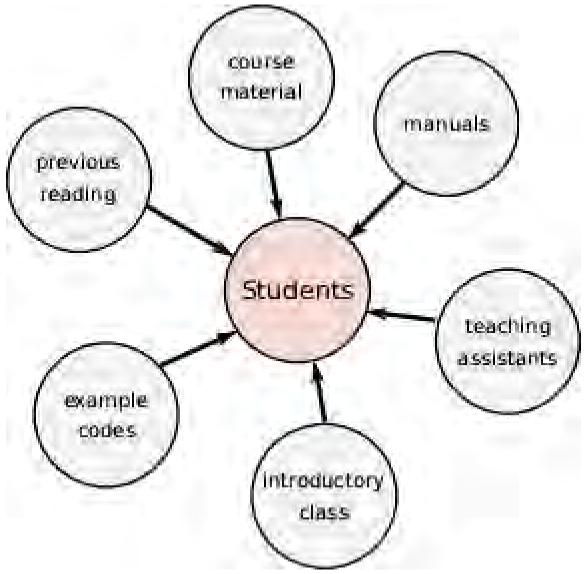
2.1 Class

The technical front aims to give students the background required to create their projects by introducing the necessary theoretical concepts and time to practice practices so that the students later can fulfil the learning objectives proposed by the course.

All classes are in the studio format (there is separation between lecture laboratory classes). Sessions are usually started by presenting to the class a challenge that addresses one of the objectives of the course and encouraging students to propose a solution to the problem (a solution encompasses a study, a specification and the programming part) .

Each class includes a student support ecosystem composed of several types of materials, as shown in Fig. 1. These materials include: Previous reading, guided study material, manuals, sample code, assistant and teacher support, and an introductory short lecture on the subject.

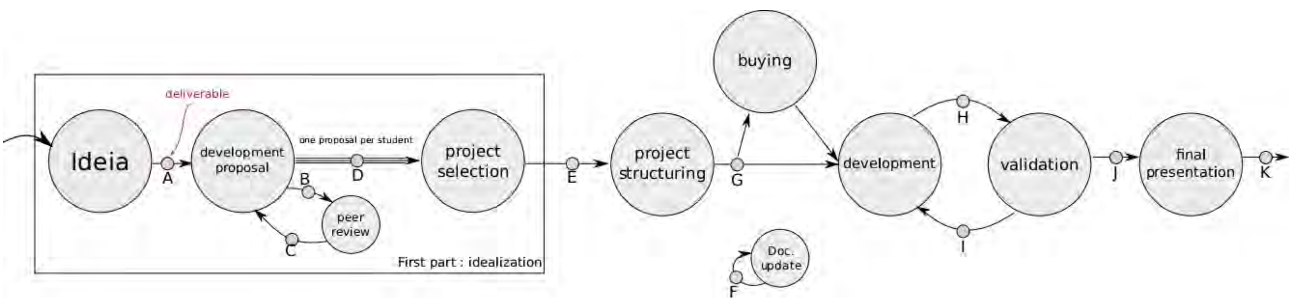
Figure 1. Student support material



2.2 Project

The projects are carried out in groups with the topic that was selected in a group dynamic. Projects should necessarily contain embedded (microprocessor) computing requirements, and should be performed using the development kit used in the classroom (Atmel SAME-70) (Wolf et al., 2000). In the course of project development, groups should update a blog with the evolution of the project, carrying out technical postings related to the project. Figure 2 details the execution steps of the project with the deliverables.

Figure 2. Project development cycle



The first objective of the proposed activities is of ideation and selection, this stage seeks to develop in the students an initial degree of critical and creative thinking, where they must search for possible problems and propose solutions based on the development of a product.

Each student must present two initial ideas and eliminate one of them with the help of the teacher. The ideas that went through the first screening are evaluated first by peers then presented to the room. In the presentation, the students must fill rate each idea on a scale of 1 to 5 according to the following criteria: Technical feasibility; Creativity; Quality of the technical proposal; Presentation quality. The sum of the points for each project is done and the best-voted projects are chosen to be executed. The goal of this step is to eliminate projects that at first seem to be innovative but actually solve a very specific core problem or to eliminate the project that none of the students (by side the proponent has interest).

After the project classification stage, the groups (between two and three students per group) are formed to execute the project, groups are created based on the students' affinity with the project. The development begins with a detailed specification of the project and a schedule to follow. Each execution stage has a deliverable, the projects are evaluated in several steps.

2.3 Reviews

Several evaluation mechanisms were used, among them: delivery of a directed study; code delivery (held in class and outside); length of deadlines; self evaluation; evaluation.

Each evaluation mechanism / stage resulted in an update of the students' learning objectives (as seen on Figure 3), and the updated table was accessible by students frequently. In order to pass the course, students must have at least all items up to the Essential level (C). In the following figure, we illustrate a part of the table with the status of a particular student in the middle of the semester. Such student had no difficulty at the beginning of the course but during the course began to miss activity deliveries and started to fail on the objectives.

Figure 3. Example of students' learning objectives

Insper

de aprendizagem se dará com base nessa tabela.

de confrontar e verificar o preenchimento

Insatisfatório (I)		Em Desenvolvimento (D)		Essencial (C)		Proficiente (B)	
Cría softwares para microcontroladores utilizando suas especificidades (periféricos/ low power)							
Consegue programar um microcontrolador com um código já existente.	Códigos 07-11	Faz pequenas modificações em um código já existente.	Códigos 07-11	Adiciona funcionalidade a um código já existente.	(18/4) - [11] Tick Tack - [12] ADC	Cria novos softwares para soluções de problemas com base em códigos de referência.	
Consegue parcialmente identificar os pontos principais de um código, mas não entende o total de seu funcionamento.	Códigos 07-11	Identifica como as partes de um código se relacionam e se comunicam.	(18/4) - [11] Tick Tack - [12] ADC	Compreende o uso das interrupções em um determinado código.	(18/4) - [11] Tick Tack - [12] ADC	É capaz de criar um diagrama de blocos explicativo do projeto.	
				Otimiza o firmware para adequar as restrições de projeto (low power/ eficiência) utilizando os periféricos.	(18/4) - [11] Tick Tack - [12] ADC		
Entende como funciona um	(18/4) - [11] Tick Tack	Não possui dificuldade com	(18/4) - [11] Tick Tack	Entende como o código se	(18/4) - [11] Tick Tack		

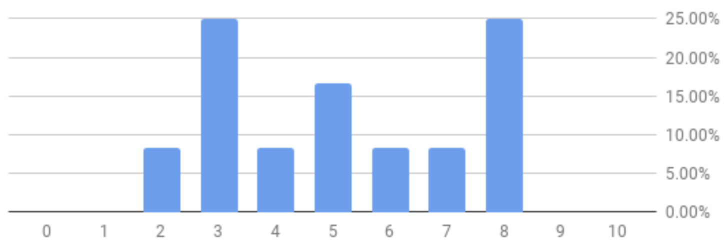
The idea of this evaluation mechanism is to keep track of the learning objectives along the semester respecting the time of each student but without losing track of their status on the discipline.

In some cases, specific students were asked to carry out a horizontal assessment to address specific doubts of the instructors related to how competent certain students where on some learning objectives. There were cases in which the evaluator was wrong and the student mastered the subject and in other cases the student was alerted of the learning deficit and a plan was made so that he could the expected points.

2.4 Results

The course was offered for the first time in 2017 for the first class of computer engineering students at Insper, to a total of 13 students. The results shown below were taken from the routine survey made by the institution at the end of the semester. The survey was missed by only one student.

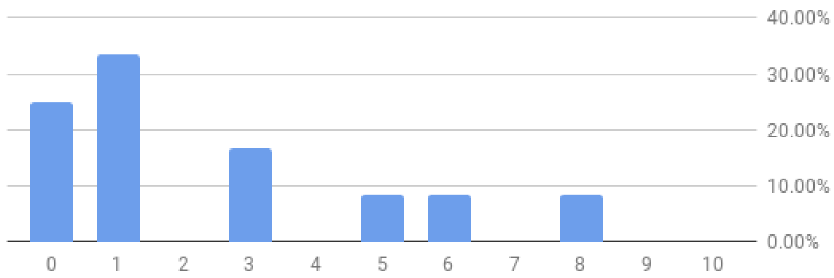
Figure 4. Survey : The contents of this course will help me in a future internship or work.



(0 being the minimum and 10 being the maximum)

Students tend to avoid hardware track sources such as this to specialize more in software, but the following survey answers show that students value the skills learning in the Embedded Computing course.

Figure 5. Survey: I'm not sure if learning this is important.



(0 means "I'm absolutely certain" and 10 means "I'm not certain")

3 Evaluation methodology

The evaluation methodology was based on decomposing the learning objectives in constituent topics. This approach proved very informative to allow the teachers to follow the evolution of the students. Some students with lower levels of autonomy complained that it was not clear for them what steps should be taken so that they would improve their grades and pass the course. Part of the students manifested the wish for a more immediate and simple solution (for example: studying a given topic for an exame) to pass the course. Other students were not comfortable that the topics were specific (for example: Add functionality to an already existing code) and related to deliveries, so they could only be observed when a delivery was made.

We are concerned that this form of evaluation may not scale well. In a class with 13 students it was feasible to decompose each deliverable and assess all learning goals for every student, but in order to scale to larger class sizes we will need to automate in some way the evaluation of deliverables and engage more help (from teaching assistants, for instance).

In addition to scalability, the table with the details of each learning objective needs be constantly revised. During the first offering of the course the table was adjusted at least four times. Even then certain decomposed learning goals overlapped or did not serve as a good measurement of students' mastery of macro learning goals.

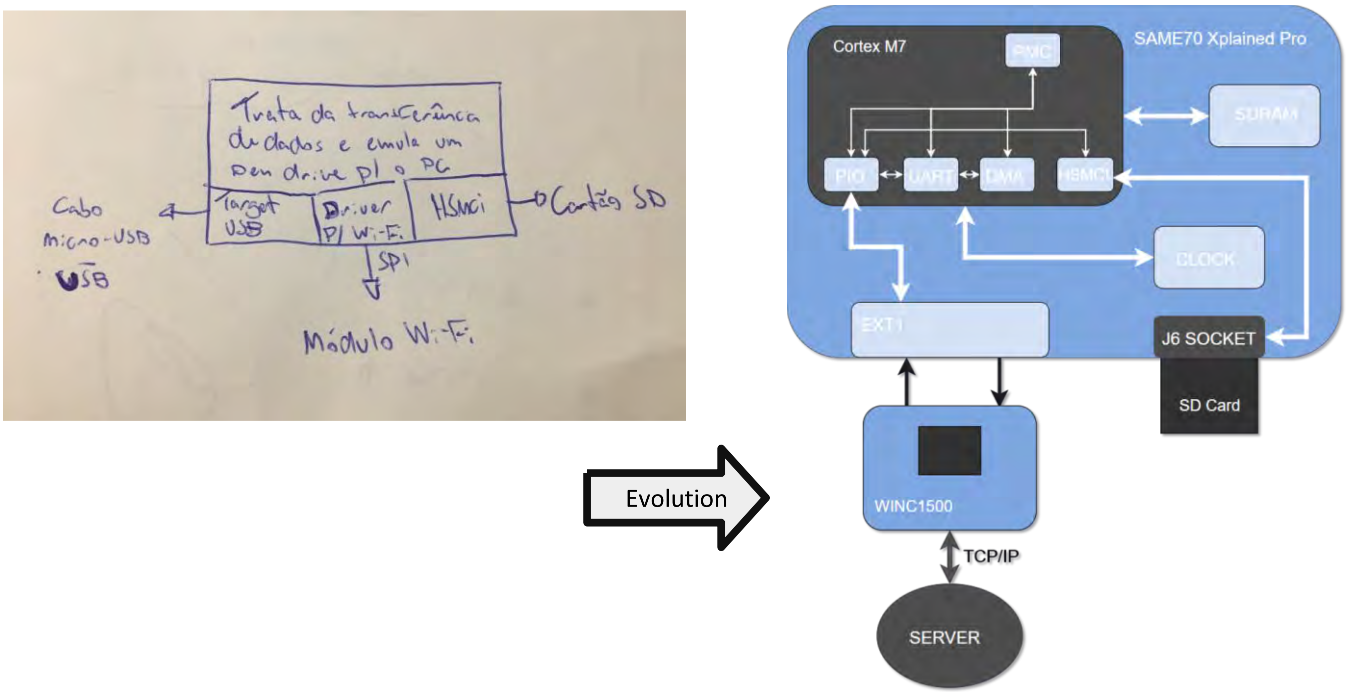
3.1 Project

in the development of the project the students were able to apply the concepts learned in the classes as well as to specialize in the chosen topics for the resolution of the project. Half of the classes were studio-type where students could work calmly on their projects and could ask specific questions for the instructors.

Students were encouraged to document the project especially through block diagrams (White, 2011). Block diagrams proved to be a great tool that expresses lots of architectural and procedural information about embedded systems, enabling the student to synthesize much of their knowledge on a piece of paper.

With the diagrams it was also possible to follow the evolution of the students in the course, Fig. 6a Illustrates one of the first diagrams of a student referring to his project and Fig 6 b the final diagram. This final diagram has many of the information needed to understand the project and well synthesizes the learner's learning curve

Figure 6. Student block diagram evolution



4 Discussion

The learning verification format proposed in this course makes it possible to work with a diversity of students, where each one can have his / her own learning pace and the verification of a specific objective does not happen in a specific way at a single moment in time, but distributed throughout the semester. The students presented resistance at first because it was not clear to them the steps required to pass the course, but at the end they were happy with this mechanism and suggested its use in others courses.

Students were very motivated with the development of the term project, as the topic was chosen freely and the final deliverable looked like a pseudo product. One of the problems of the project was the level of commitment in the execution, as it was a single project throughout the semester students were not so dedicated at the beginning, which ended up hindering the execution of the project for some groups.

One possible solution to this issue would be to break the project into small deliverables to try to maintain a high level of dedication to the project since the beginning of the semester, though it is not clear if this approach is suitable for this Embedded Computing course. Since this class is of an intermediate to advanced level, maybe a preferable approach would be to make students aware of the dates and quality required for the final delivery and have them manage their own projects. This latter approach is arguably more similar to what they would need in a workplace setting.

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Application of the eduScrum methodology to a higher education institution in the Amazon

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Abstract

The objective of this work is to report the implementation process of the eduscrum methodology in the postgraduate courses in industrial engineering at a faculty located in the Amazon. EduScrum is a collaborative learning strategy and an effective management framework for group projects that enhances student engagement and development of a mind-set that aims for constant improvement. The text presents the history, facts and concepts about eduscrum and the step-by-step process of technology transfer between the proposer of the technique and the institution of higher education. The difficulties encountered and the adaptations necessary to apply the technique in the Brazilian educational scenario are detailed. The text presents the results obtained in the first 18 months of implementation of the methodology and the main competences developed by the teachers to adapt to eduScrum.

Keywords: Active Learning; Engineering Education; Student engagement; eduScrum.

1 Introduction

The use of agile methodologies is growing rapidly in the information technology industry. For Scott *et al.* (2014), Scrum is widely used in computing companies by increasing team productivity, quality, and customer satisfaction. Simultaneously with industry, educational institutions also focused on the use of agile techniques in the academic environment, leading Scrum to become an effective strategy for preparing students to meet the challenges of the job market.

In 2013, the Dutch professor of science, Willy Wijnands, proposes a pedagogical application of Scrum. He is the initiator and founder of EduScrum and uses Scrum's ceremonies, roles, and tools in the classroom.

For Devedzic & Milenkovic (2011), the EduScrum framework, when applied in education, reinforces students' skills gain, which is motivated by facing real day-to-day work problems rather than doing tests or theoretical exercises.

According to Zapater et al. (2013), the combination of agile methodologies and problem-based learning (PBL) in education promotes students' engagement in real work tasks with real constraints on work costs and capacity, which leads to understand how to handle complex systems. It also creates conditions for cooperation and teamwork in a self-regulated environment. Students should be able to organize themselves, dividing the work in a way that allows them to learn and integrate what was produced by the group, proposing a solution to the problem. For effective teamwork, they need to understand the benefits of good planning and the use of development tools.

Still according to Zapater et al. (2013) in this scenario students are faced with a problem that needs to be solved and learn new techniques in the areas involved in the design and implementation of their solution. For this, they should be encouraged to find their own solutions to a problem, becoming proficient in certain areas or through the advice of experts.

In order to guarantee the best results in the teaching-learning process, the teacher needs to develop a set of skills in order to prepare the classes, apply the appropriate didactic resources in face-to-face meetings and correctly evaluate the students' understanding of the developed studies. Without the development of these skills, the course does not unfold under the right conditions. EduScrum decrees the end of the exclusively expositive classes and the use of didactic material in the traditional format.

2 Description of eduScrum

For Ferreira and Martins (2016), students are divided into groups and are given to them a set of requirements to train skills related to problem solving, communication and project management in a controlled environment. The groups can be formed by the students or defined by the teacher. During a sprint, which is a period of work, the group needs to develop or solve a set of activities related to the learning objectives of the course.

According to Ferreira and Martins (2016), activities can be broken down into several tasks. This process uses the Fibonacci sequence (1.1, 2, 3, 5, 8, 13, 21, ...) to define the complexity and estimate the amount of effort to implement each piece of work. For Mahnic (2012), in the progress of activities, Scrum uses problem-solving practice, and therefore, students develop the skills of estimating the efforts of each task, planning the work, monitoring the speed of delivery of the tasks. and completeness of tasks.

EduScrum has 3 ceremonies: stand-up, sprint review and sprint retrospective. The stand-up occurs at the beginning of a school day and sharpens students' focus on work mode. In the sprint retrospective, the group should write a brief review of the 3 issues related to team performance during the sprint: what went well, what went wrong and what needs to be improved in the next sprint. Already in the sprint review, eduScrum artifacts are updated and the actual status of the project can be gauged. For Scott et al. (2015), during the sprint review, the team must present what was done during the sprint so that the teacher examines the work done and gives feedback.

Figure 1 shows the stages of the eduscrum framework. For Dinis-Carvalho *et al.* (2017), in the beginning, a set of requirements is organized by the teacher forming the product backlog. Tasks are grouped into sprints, with each sprint having a subset of the product backlog. Throughout the sprint team members get involved with the activities and have to deliver some product at the end. It could be, for example, a report with the solutions found for a problem.

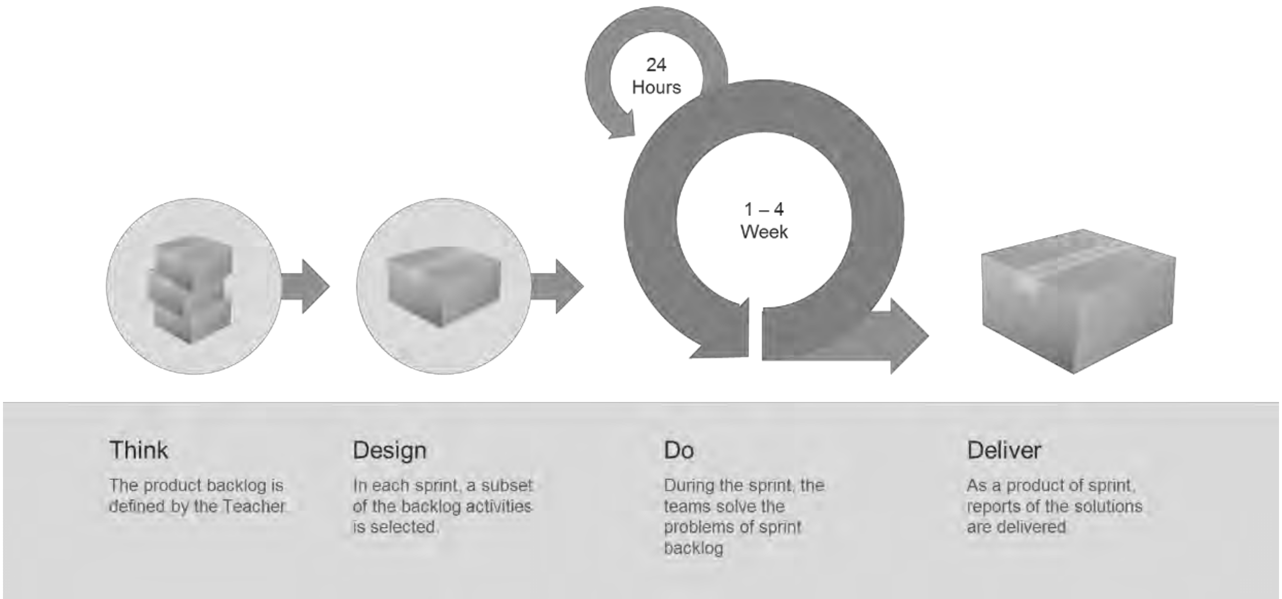


Figure 1. Scrum framework diagram for education.

Figure 2 shows the 3 roles of eduScrum are product owner, scrum master and team members. The product owner in eduscrum is the teacher who manages and defines the product backlog. The scrum master is one of the team members who guides the teams so that the Scrum rules are properly conducted. All others from team members develops the requirements.

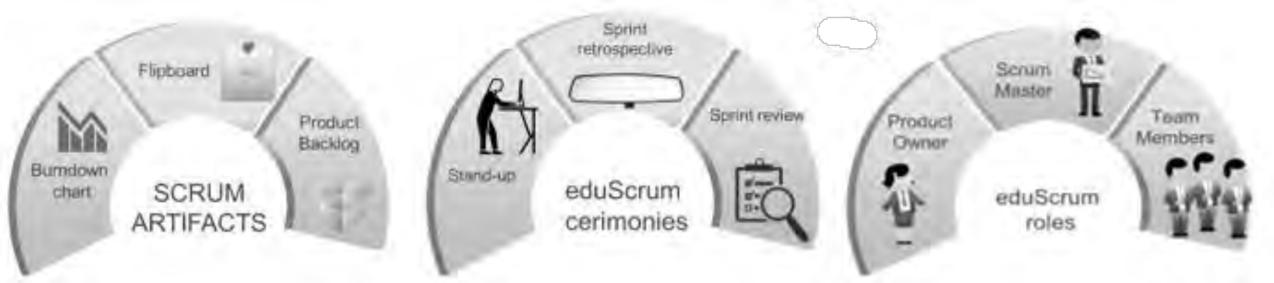


Figure 2. Artifacts, ceremonies and roles eduScrum

Besides the product backlog, eduscrum has two other artifacts: the burndown chart and the flipboard. The flipboard is a simple 3-column table: To Do, In Progress, and Done. At the beginning of the first sprint, all tasks are allocated in the To Do column. As they begin, they are shifted to "In Progress." When you complete an activity, the group moves it on the flipboard to the "Completed" column. The burndown chart allows the group to control the use of the. Time and how the activities will be developed in each sprint.

3 Teaching skills

During the initial 18 months of implementation of the eduscrum methodology at IDAAM Faculties, several challenges were encountered. Teachers underwent trainings and needed to adapt the supporting texts of the subjects, the dynamics used in the classroom and the use of time in face-to-face meetings. The assignments of degrees to the students started to be upon the deliveries of the teams and not related to the individual performance. In this process, some teaching competences were more strongly highlighted as priorities. Figure 3 presents a conceptual map of these skills.

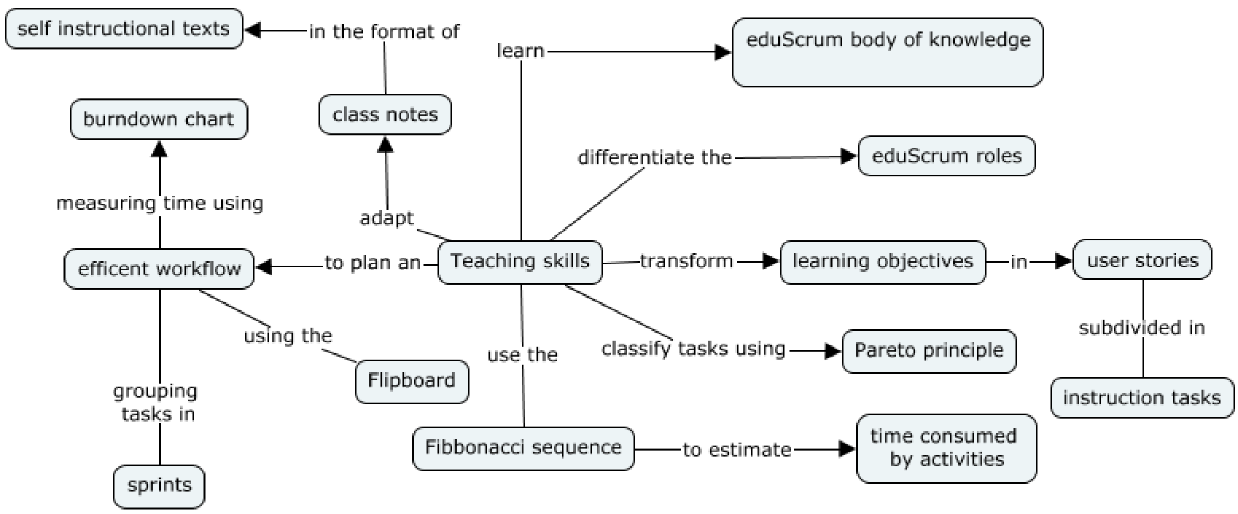


Figure 3 - teacher skills concept map

The methodology applied in this work is summarized the qualification of the body of teachers, with specific training in the teaching competencies identified as priorities. It is an action research focused on the development and articulation of teachers in the application of eduscrum in 4 specific dimensions: eduscrum body of knowledge, lesson planning, class execution and writing of supporting texts.

The first dimension concerns the study and understanding of the philosophy behind the eduscrum and the guides and manuals developed by its proposer Willy Wijnands. The second dimension involves applying the correct division of roles experienced by students and teachers, transforming learning objectives into user stories, and prioritizing planning, time and resources of instructional activities. The third dimension encompasses efficient classroom workflow with the use of features such as the flipboard and the burndown graph. It also covers the grouping of activities in sprints and the management of deliveries and deadlines. The last dimension concerns the transformation of class notes into self-instructional texts that allow the advancement of teams without the constant intervention of the teacher and thus give greater autonomy to eduscrum teams.

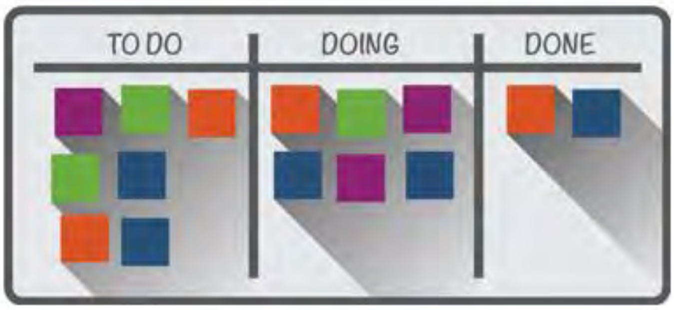
For Bettio et al. (2013) there is a similarity between class preparation, learning objects construction, and software development. In the educational process, the requirements are set by the teacher (Product Owner). This group of requirements is called Product Backlog. For the same author, in each development cycle, called a sprint, a meeting called Stand-up is done in a way to select a set of requirements for implementation. This group of requirements is called sprint Backlog. Once activities are defined, the development cycle (Sprint) is started. The loop is executed until the tasks are completed, or the time set for the sprint is reached. Requirements can be added or removed. A characteristic of Scrum is the stable tempo of a sprint. It is expected that at the end of a sprint, that a group of requirements has been finalized. At this point, a retrospective is done to identify issues and solutions that will be used in the next sprint.

In the process of transferring methodology from Ashram College to IDAAM, there was the direct participation of Professor Willy Wijnands. As initial skills, each local teacher received the eduScrum user's guide. This body of knowledge integrates the main facts and concepts of Eduscrum, such as roles, ceremonies, and artifacts.

After this initial stage, the learning objectives of each discipline are elaborated. These are written in the form of user stories. The objectives are then broken down into activities with order of prerequisites so that at the end of them the proposed competence will be consolidated by the participants. These tasks are classified using the Pareto principle, so that if there is a time constraint, the activities that are a priority are clear. These activities at this planning stage have the estimated time of achievement using the Fibbonacci sequence or the poker cards.

With the work sequence developed, the workflow is planned. This is done by grouping the various product backlog activities into sprints that last on average 21 days. For the visual management of the work two artifacts are used: the flipboard and the burndown chart. The first one helps to control the running tasks, avoiding the situation where many tasks are started without being completed. It also allows to monitor if there are blocked tasks that require the direct intercession of the teacher. Burndown shows whether students are on time, whether they are early or late. This allows the elaboration of contingency plans. Figure 4 shows this two artifacts.

In order to adapt the flow of lessons to the new model, the supporting texts in traditional format need to be adapted. This is where the instructional notes of class come in, creating a context of greater autonomy for the work of the teams.



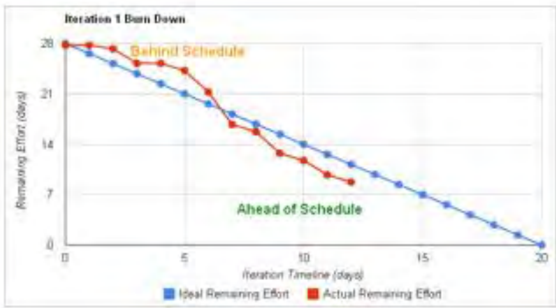


Figure 4 – Flipboard (left) and burndown chart (right)

4 Conclusion

After one and a half years of work, eduScrum has not yet been fully deployed. However the results achieved have already made the classes more skill developers. The meetings are less and less composed of traditional expositive presentations. Students are more engaged and activities are more like day-to-day work: participatory problem-solving meetings. The growth and ripening curve is slow but promising. The results achieved to date are based on the training of teachers and the flexibility of the faculty to adopt the methods, principles and values of eduscrum. For future work, comparisons will be made in the opinion polls of students before and after the implementation of eduscrum to evaluate the level of students' adherence to the new method.

5 Acknowledgements

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Toward an innovative approach to understand and apply the Inclusion–Exclusion Principle

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Abstract

The Inclusion-Exclusion Principle is well quoted in mathematics and it states a measurement for the number of non-redundant elements in an arbitrary set A, which results from the union of several correlated subsets. The correlation between two or more subsets is nonzero if there exist at least one element in common; otherwise, there is no redundancy between all the subsets, and the overall number of elements, that is, the overall cardinality is a simple summation of the individual cardinalities. The general expression for the application of the Inclusion-Exclusion Principle has a non-trivial format, including multiple sommatories of positive and negatives terms, being an excellent opportunity to used methodologies based on active learning. Purposing to promote a meaningful learning about the principle in point, this paper covers a new and gamified procedure for counting the non-redundant elements in a union set, with theoretical explanations and experimental testing. Results of a group of undergraduate students meet expectations about motivation, engagement and learning at higher levels considering Bloom's taxonomy.

Keywords: Inclusion-Exclusion Principle; Gamification; Education; Bloom's taxonomy.

1 Introduction

In the present days, a software engineering need knowledge from several domains, and a solid mathematical foundation is one of them. The third version of the Guide to the Software Engineering Body of Knowledge (SWEBOK) dedicated an entire chapter (Chapter 14) to this theme (IEEE, 2014).

In this mathematical foundation lies several fundamental concepts, as set operations and basics of counting. These concepts are combined in the two main combinatorics principles: the multiplicative principle, that counts the number of elements in the cartesian product of two non-empty sets, and the additive principle, that counts the number of elements in the union of two non-intersecting sets (Santos, Mello & Murari, 2007).

The Inclusion-Exclusion Principle is the generalization of the additive principle, for N sets which can form one or more pairs with non-empty intersections (Mazur, 2010). The more familiar case ($N = 2$, i.e., only two sets) is explicit shown in (IEEE, 2014), in a Venn Diagram.

The general case, however, can be not illustrated by Vein diagrams, and have a complex mathematical representation of multiple summations with several indexes (Wallis & George, 2017), as shown in Eq. (1)

$$n(A_1 \cup A_2 \cup \ldots \cup A_N) = \sum n(A_i) - \sum n\left(A_i \cap A_j\right) + \ldots + (-1)^N n(A_1 \cap A_2 \cap \ldots \cap A_N) \quad (1)$$

In general, the proof of the expression in Eq. (1) is made by mathematical induction of by a combinatorial argument (Allenby & Slomson, 2011).

The representation of the Inclusion-Exclusion Principle presented in Eq. (1) can be a barrier to the student at first sign, and can hide the fundamental idea of the principle: if we not track the intersections carefully, the final counting will be off by excess (by adding duplicates) or by lack (leaving off some terms) (Morgado, Carvalho, Carvalho & Fernandez, 1991).

In Faculty of Gama, the Inclusion-Exclusion Principle is part of the curriculum of the discipline entitled “Discrete Mathematics I”, a one semester class with a hundred or more students. This high number of students can be a challenge for the teacher, that must search for dynamic approaches that promote the engaging of the students without loose the mathematical rigor and precision (Felder, 1997).

This work proposes a dynamic and innovative approach to the Inclusion-Exclusion Principle that have three main goals: engaging the students in a collaborative-competitive task involving the principle fundamental ideas, presents an innovative visualization of the principle, by means of a two-dimension table, and make a bridge between the intuitive visualization and the formal mathematical notation.

In the next section we present the proposed approach for the Inclusion-Exclusion Principle. In Section 3 we describe the methodology adopted for the experiment conducted to validate the proposal. In Section 4 we discuss the results of this experiment, and in the final section are the conclusions and the future work.

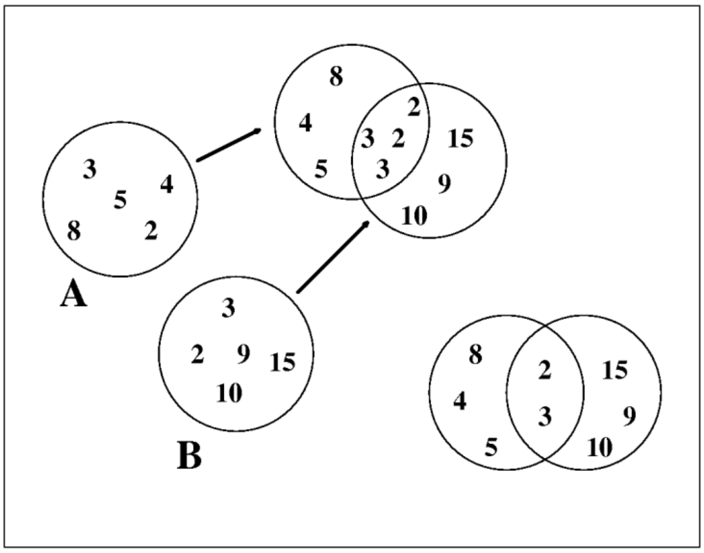
2 Proposed approach for the Inclusion-Exclusion Principle

It is presented in the following lines a new methodology for application and understanding of the principle of inclusion-exclusion. At the beginning, it was expected that the innovative approach sketched below could bring some advantages over the traditional method exposed in Eq. (1), due to its visualization and mathematical simplicity. In fact, it assumption has been proved true later through classes experiments, and the results are shown in Section 4.

In many cases the lack of in-depth knowledge with mathematical notations, combined with some abstraction needs, might turn the mathematical learning into a difficult task. In theory, mathematics must be based on pure reasoning, even before it goes to a piece of paper.

For example, let assume a simple problem of counting the number of non-redundant elements in an arbitrary union set$A \cup B$using the Venn Diagram (Edwards & Stewart, 2004). It is known that the Venn Diagram is a very useful graphical strategy for several mathematical properties understanding, inside logical structures, probability, Boolean operations and even for effective information retrieval (Koike, Sato, Kobayashi, Tobita & Kobayashi, 2000). Figure 1 shows the Inclusion-Exclusion Principle for two sets.

Figure 1 – A very simple application of the Inclusion-Exclusion Principle.



By using this approach, it is possible to see, with no mathematical complications, that exist some commons elements in both sets **A** and **B**. So, adding sets **A** and **B**, one needs to subtract their intersection, one time, to avoid redundancies. Unfortunately, the Venn Diagram gets difficult to apply for more than three sets, and so, the need of the general formulation for the Inclusion-Exclusion Principle arises.

Let now consider the problem of counting the non-redundant elements in an arbitrary union set $A \cup B \cup C$. What happens to this summation after the A cardinality inclusion? Considering the Inclusion-Exclusion Principle, every intersection with set A is affected. This partial result is shown in Figure 2.

Figure 2 – Partial results to the union set $A \cup B \cup C$ cardinality – effects of $n(A)$ set inclusion.

	$+A$
A	1
B	0
C	0
$A \cap B$	1
$A \cap C$	1
$B \cap C$	0
$A \cap B \cap C$	1

Now, let generate others two columns, by adding to this summation the sets B and C. The inclusion of set B affect the same intersection $A \cap B$, as well the inclusion of set C affects the intersection $A \cap C$. At this moment, there might exists many redundancies, according to the graphical notation used. The intersection set $B \cap C$ also gets affected twice after the inclusion of these two sets (see Figure 3).

Figure 3 – Partial results to the union set $A \cup B \cup C$ cardinality – effects of $n(A), n(B)$ and $n(C)$ inclusions.

	$+A$	$+B$	$+C$	$-A \cap B$	$-A \cap C$	$-B \cap C$	$+A \cap B \cap C$
A	1	1	1				
B	0	1	1				
C	0	0	1				
$A \cap B$	1	2	2				
$A \cap C$	1	1	2				
$B \cap C$	0	1	2				
$A \cap B \cap C$	1	2	3				

Finally, the inclusion of sets A, B and C gets the intersection set $A \cap B \cap C$affected three times. Considering the Inclusion-Exclusion Principle, the final result must be obtained after redundancies elimination. Step-by-step, in each column, the "gamified" application of the Inclusion-Exclusion Principle is shown in Figure 4.

Figure 4 – Final results for the union set cardinality $n(A \cup B \cup C)$.

	$+A$	$+B$	$+C$	$-A \cap B$	$-A \cap C$	$-B \cap C$	$+A \cap B \cap C$
A	1	1	1	1	1	1	1
B	0	1	1	1	1	1	1
C	0	0	1	1	1	1	1
$A \cap B$	1	2	2	1	1	1	1
$A \cap C$	1	1	2	2	1	1	1
$B \cap C$	0	1	2	2	2	1	1
$A \cap B \cap C$	1	2	3	2	1	0	1

In the fourth column of Fig. 4, the subtraction of $A \cap B$ affects the union set $A \cap B \cap C$. In the next two columns, the extraction of $A \cap C$ and $B \cap C$ elimines $n(A \cap B \cap C)$ totally. The next and final step makes the seventh column, by addition of the intersection $A \cap B \cap C$.

Following the same procedure, the presented approach can be used to obtain the union of multiple sets, helping students to understand the general formulation and application of the Inclusion-Exclusion Principle, and its variations.

3 Material and Methods

To prove the efficacy and efficiency of the new approach, eighty-six software engineering students of the "Discrete Mathematic I" graduation course, of the University of Brasília, at the Faculty of Gama, have been submitted to a gamified group-dynamic, about the Inclusion-Exclusion Principle. The whole procedure included:

1) three mathematical problems as advance organizers following the idea of meaningful learning (Ausubel, 1968) (~15 min);
2) a short explanation about the Inclusion-Exclusion Principle, using two and three sets (~20 min);
3) explanation of the new approach, repeating the last problem solution, with three sets (~15 min);
4) challenger: the four-union set $A \cup B \cup C \cup D$ problem, using the new approach (~15 min);
5) presentation of the general formulation for the Inclusion-Exclusion Principle (~10 min);
6) a subjective evaluation aimed to the comparison of the two exposed methodologies.

In the first step, the initial advance organizer has been used to optimize the meaningful learning in many educational areas, including the science teaching (Ausubel, 1968; Moreira, 2012). The advance organizer, composed by three mathematical problems, was constructed firstly in way to engage the students in a collaborative ambient, and secondly to motivate them to the need of the Inclusion-Exclusion Principle application.

The steps following steps 2, 3, 4 and 5, were created according to the cognitive domain of the Bloom's Taxonomy (Conklin, 2005; Vaughan, 1980; Bloom, Hastings & Madaus, 1971). Steps 2 was created to help the students to remember the solutions for the Inclusion-Exclusion's problem considering two and three sets. At this point, after the initial advance organizer, the students could apply their knowledges in a way to keep short the distance between the problem and its numerical solution, using the constructed principle.

Now, in the step 3, the innovative approach was presented to the students, aiming their comprehension over the graphical and logical scheme. After that point, in the steps 4, the students were subjugated to a challenger, aimed to the application of the new approach, over the same three set's problem. Finally, in the step 5, the traditional formulation of the Inclusion-Exclusion Principle was presented to the students.

After each group presented a successful solution for any of the proposed problems, rewards have been provided. A total of twenty-two groups of four or five students took part of this event.

Figure 5 – Software engineering students taking part of the group dynamic for validation of the new Inclusion-Exclusion Principle approach.

At the end, subjective evaluation was applied using the questionnaire below.

Regarding the Activity:

1. How was your previous knowledge regarding to the Inclusion-Exclusion Principle?
    a. I already knew.
    b. I knew it for the case of two and three union set.
    c. I knew it for the case of two union set only.
    d. I have never heard about it.
2. In your opinion, for the understanding of the Inclusion-Exclusion Principle:
    a. The new approach is better than the general formulation.
    b. The general formulation is better than the new approach.
    c. Both are easy to understand.
    d. Both are hard to understand.
3. Regarding to your understanding and comprehension to about the Inclusion-Exclusion Principle, the new approach:

a. Completely helped
b. partially helped
c. Partially disrupted
d. Completely disrupted

4. Among the presented dynamics, which of them should be applied in the common context of the "Discrete Mathematic I" course?
    a. Teamwork
    b. Gamifications
    c. Rewards
    d. Challengers
5. Your evaluation about that extra activity: Very Bad ◯ ◯ ◯ ◯ ◯ Very Good

Put here your reviews, suggestion and comments about this activity:

(lines)

All students answered the questionnaire at the end of the activity. The data were tabulated, and the results are found in the next section.

4 Results and Discussion

Starting from the general statistics, the obtained data pointed a "very good" evaluation for 80.23% of the students. Others 14.63% found it "good", and 8.14% don't manifested themselves. More general results are shown in Table 1.

Table 1 – General statistics obtained from the subjective evaluation.

Items	Percent (%)	Items	Percent (%)	Items	Percent (%)	Items	Percent (%)
1.a	6.98	2.a	84.88	3.a	61.63	4.a	74.00
1.b	41.86	2.b	0.00	3.b	0.00	4.b	71.00
1.c	16.28	2.c	13.95	3.c	37.21	4.c	65.00
1.d	34.88	2.d	1.16	3.d	0.00	4.d	60.00

The data was also stratified in the following tables, to understand how much the new approach have seen positive for the students with full previous knowledge, partial previous knowledge and none knowledge about the subject.

In Table 2 are the statistics for the students with full previous knowledge about the subject. These students shown no difficulties on both new and traditional methods, and most of them believes that the new approach helped them, at some subjective degree, to understand the Inclusion-Exclusion Principle.

Table 2 – Statistics for the students with full previous knowledge about the subject.

Already Knew	
50.00%	Found both methods easy to understand
50.00%	Found the new approach better

16.67%	Said that the new approach helps completely
83.33%	Said that the new approach helps partially

Table 3 shows the results for the students with some previous knowledge about the subject. This group had the best response (almost 9 of 10 students) to the new approach, and most of them found the new approach useful to their understanding of the principle. These and the students listed in Table 2 do not found the new approach hard.

Table 3 – Statistics for the students with some previous knowledge about the subject.

Knowledge about two and three sets applications	
11.11%	Found both methods easy to understand
88.89%	Found the new approach better
58.33%	Said that the new approach helps completely
41.67%	Said that the new approach helps partially

Statistics for the students with a short previous knowledge about the subject are listed in Table 4. These students form the only group that manifested some difficulty to understand the new method. Besides this fact, the results are very similar to the responses shown in Table 3.

Table 4 – Statistics for the students with a short previous knowledge about the subject.

Knowledge about two sets applications only	
7.14%	Found both methods easy to understand
7.14%	Found both methods hard to understand
85.71%	Found the new approach better
57.14%	Said that the new approach helps completely
35.71%	Said that the new approach helps partially
7.14%	Don't manifest themselves

Finally, Table 5 shows the results for the most interesting group: the students with none previous knowledge about the subject. These students also have a strong response to new method, and the new method was most useful to them (76.67% said that the new approach helped them completely). This group was the primary target of the new method, and these responses shows that the method fulfil its objective.

Table 5 – Statistics for the students with none previous knowledge about the subject.

	None previous knowledge
13.33%	Found both methods easy to understand
86.67%	Found the new approach better
76.67%	Said that the new approach helps completely
23.33%	Said that the new approach helps partially

To facilitate the exposition of student's reviews, suggestions and comments it was elaborated the word cloud shown in Figure 6.

Figure 6 – Word cloud from the subjective evaluation.

At the end, the students pointed out many conditions for a satisfactory learning, congratulating everyone involved in the executed activity. In general, all of students took part of the activity, in an excited, because of the challenges, and productive atmosphere, as it can be seen in the word-cloud – many initial objectives were clearly identified by the class.

5 Conclusion

The obtained subjective data shows that the pedagogical strategies administered in this activity can provide significant results over the learning processes. One of the most difficult aspects inside a classroom is learning how to motivate your students, and in this context, the problem's gamification arises as one of the most relevant resource for teachers.

Students became more motivated to learn when it happens in well programmed steps, with appropriated and levelled objectives, at each step of knowledge. The Bloom's Taxonomy proved very effective in the planning of this class, once it is possible to notice the exactly moment when the problems occur. By using the Bloom's Taxonomy, it is also possible to measure the right information dosage during the learning process, making the subject easier to the student's learning.

The dynamic of the method demands a large room to accommodate the groups and to minimize the discussions noise. Its also required the support of a few monitors to check the answers proposed by the students. The main challenge presented in the implementation was to stop the students discussions and regain their attention to advance to the next planned step.

Regarding to the innovative strategy presented, it was satisfactorily received by the students. As expected, the most critical group of students, without prior knowledge on the subject, provided the best feedback about the new method. Groups with some knowledge already constructed also expressed a positive opinion about the new method. Based on the obtained results, at the end of the activity, the innovative strategy was well validated for the understanding and application of the Inclusion-Exclusion Principle.

The results obtained and the students' comments motivated the authors to plan new applications of the method with the same subject (Principle of Inclusion-Exclusion) with other classes in the following semesters.

There were no difficulties in applying the methodology, however, we saw with students the need for achieving a balance on the time available for the activities. Some groups have requested a longer time to comfortably fulfill the advance organizers steps and challenges.

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Remodeling Computer Networks into a Cloud Computing course: from a theoretical to a totally hands-on course

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Abstract

A new course was designed, with Cloud Computing as a main focus, and with computer networks concepts split throughout different parts. The students were assigned a series of hands-on activities, starting with hardware management, private-cloud deployment, and finishing with a final project employing cloud resources. All the activity handouts were made available from the start of the course, and the students have been allowed to complete them by their own pace, which means that, on a given time, everyone was potentially working in a different task or content. The instructor acted mostly as a consultant, or a coach, in addition to the role of lecturer.

Execution of this proposal was challenging and only possible because the program was restructured into a more hands-on course. Without the group-speed constraint, often set by the pace of the slowest student, it was possible to observe a high motivation level in finishing the tasks. One explanation could be that students do not need to wait for others to get in sync with the course content, a factor that often leads to amotivation. Students were autonomous in allocating their free time into the activities, without loss of quality. One mapped disadvantage could be the development of a persistent slow pace by some students, which can be mitigated by active feedback.

Keywords: Active Learning; Engineering Education; Computer Networks, Cloud Computing.

1 Introduction

Computer Networks is a traditional course in a Computer Science or Computer Engineering program. Although technology evolves real fast, a basic bibliography for this subject usually contains consolidated material in this area that has had just minors update since their first release (Tanenbaum & Van Steen, 2007; Kurose & Ross, 2014; Comer et al., 2016). In this traditional program, subjects like Compute and Storage are usually covered in others isolated disciplines.

Cloud Computing is a new paradigm that has been growing in late years, where Networking, Compute & Storage are not isolated subjects. They are all connected and new working groups in companies have been reflecting this shift, as exemplified by the popularization of DevOps concept. In special, networking has been transcended into new environments, where routers, switches and everything exist into a virtual environment (Kavis, 2014; Patterson and Fox, 2013; Erl et al., 2013; Jackson et al., 2015; Portnoy, 2016; Geng, 2015).

A course remodelling was necessary to achieve those new skills, while presenting all subjects separately seemed not the best way. Other universities have been adapting their program into this new paradigm too (University of Wisconsin-Madison; Carnegie Mellon University).

The main focus of the network bibliography cited above is on performance and robustness, letting application or real case scenarios in second plan. A traditional Computer Networks course usually spends most of the time discussing the obsolete OSI model or the TCP/IP model (usually split into 5 layers: Physical, Link, Internet, Transport and Application).

As some network content was still necessary for cloud studying, our proposal was break them into three disciplines without losing much theoretical information. Physical and Link Layers were moved into an earlier discipline, called Physical Layer of Computation. The Application layer has been pulverized among other disciplines (Web Technologies, Software Design, Agile Development, Big Data, Cloud Computing itself, etc). Internet and Transport were the only remaining layers, introduced into a Cloud context, in a very hands-on situation inside the handouts explained later in this paper.

As a consequence, the learning goal of the discipline has changed into introducing Cloud Computing paradigm, adopting as secondary goals discussing about basic computer networks, software deployment and distributed systems introduction. This paper describes how the Cloud Computing course was redesigned from a traditional Computer Networks course focused on Quality of Service (QoS) to a discipline almost a hundred percent practical that focuses on modern Cloud Computing scenarios.

2 Methodology

The students have been divided into groups of 2 or 3 according to their preferences without any constraints. The pace affinity was not a concern and they would settle it inside the group. Each one had a simple off-the-shelf hardware available, as illustrated in Figure 1, composed by 6 computers:

- Intel NUCs with I5 mobile processor
- Between 4Gb and 16Gb of RAM memory
- 2 SSD disks, one 120Gb and one 500Gb

And network equipment:

- 1 managed switch 8 ports
- 1 simple router

Figure 1 – The hardware available for each group

2.1 Handouts

We designed 7 handouts, each one with different estimated duration. Handouts are essentially practical and do not require synchronization among groups. Each group work was encouraged to work on their own pace. While some groups developed some skills faster than others, all were able to advance in their roles independently.

Some of the traditional content of computer networks was presented in the handouts when needed. Instead of a theoretical approach, they were presented in order to deal with real problems, configuration or performance issues. The downside is that not all old content can be fit in the context of cloud computing. In the other hand, many new multi-disciplinary topics have been added, bringing the discipline into the real world cloud concept.

Every handout is formatted with previous reading preparation, activities and questions, which can be divided into 4 categories:

- Preliminary questions: try to extract the previous knowledge and the first understanding of previous reading. It helps to measure how much knowledge the group have in the beginning of the handout.
- Activities questions: many activities have incomplete or defective tasks, in a certain increasing degree of difficult. The group needs to research and fill out the gaps. It helps to confirm if some intermediary activity was accomplished.
- Complimentary questions: questions almost unrelated to the activities, but bring up some related topic. It helps to bind the complimentary content into a major subject. Usually demands a certain time researching.
- Conclusion questions: The preliminary questions were presented again, but this time the students answered after completing the handout. They are related to all activities in the handout. The answers should be compared to preliminary ones in order to measure their advance in course. Additionally, a final question brings up a discussion about the pitfalls of the technique and how they could solve them, introducing the topic of the next handout.

It is important to notice that for most of the activities, they don't need to have physical access to the hardware, except for Handout 2 and some small parts of the other ones. The next subsections will explain all the 7 handouts content and their hour estimation for conclusion.

2.1.1 H1 – Public Cloud Introduction – 4 hours
It introduces the main concept of Cloud Computing. It focuses on discussing about Public, Private and Hybrid model and their advantages. Some practical tasks on Public Cloud are demanded.

2.1.2 H2 – Metal as a Service – 16 hours
The group starts to work with their hardware, installing and managing a bare-metal orchestrator. Physical networks concepts are also discussed. At the end of this guide, they will have all hardware prepared for a Private Cloud deployment.

2.1.3 H3 – Juju – 8 hours
Juju is a software deployment orchestrator, acting over the bare-metal. All groups must understand how it works and how to create their own deployment script, which might be useful in the final project.

2.1.4 H4 – Openstack – 10 hours
The Private Cloud Distribution chosen was Openstack's Canonical. It is market leading technology, but it is also too much fragmented. After finishing this handout, all groups are prepared to begin their final project and will have moderate understanding about Virtual Machines and Virtual Networks.

2.1.5 H5 – Real Solution Deployment – 4 hours
This is the less practical guide, with discussion about non-functional requirements and how cloud paradigm could minor common deployment issues, like Disaster Recovering. It demands some research and reading, and presents to the students a real world example, outside their usual sandbox.

2.1.6 H6 – Kubernetes – 12 hours
It presents a Container orchestrator that could operate over Private/Public Cloud. Advanced concepts like Load Balancing, Autoscalling or ReplicaSet are demonstrated through activities. They could improve their skills by updating the final project with new features. This is the first optional handout.

2.1.7 H7 – Private Cloud Extra Topics – Indefinite hours
Basically it goes further in cloud understanding, asking the group to install another Openstack distribution. They will have to manually configure the new setup, which will demand high technical skills when dealing with networking and sysadmin concepts. If completed, this guide evaluates the group into the maximum grade.

2.2 Short lectures

The guides cover most practical skills important in the context of cloud computing. However, there are notable gaps in the content with regards to computer networks or solution architecture. These topics are presented in short expositive lectures of 15-20 minutes every week. Instead of being just presentations, these lectures were designed to encourage students to engage in discussions and to relate the content with subjects from other courses. Since cloud computing is being used in many different contexts, from big enterprises to lean startups, these discussions are an opportunity to understand which solutions are more adequate to which contexts with regards to non-functional requisites such as scalability, security and fault tolerance.

It was also offered to students the possibility of presenting a short lecture in subjects of their interest. This activity is optional and is not taken into account for grading. Nonetheless, a feedback was given regarding the clarity of the presentation and the mastering of the subject.

2.3 Assessment

The course is graded using 6 different levels: Insufficient (I), In Development (D), Acceptable (C), Good (B), Great (A) and Outstanding (A+). Students are evaluated using the 7 handouts and a final individual project. The final grade is the minimum between the handout grade and the individual project assessment.

To earn grades (C), (B), (A) and (A+) in the handouts, the groups must complete, respectively, 4, 5, 6 and 7 guides. There are no half grades; deliveries are either completed with success or pending corrections. Guides pending corrections are annotated and returned to students, which must address all points for a new evaluation. This feedback loop continues until all points are correctly addressed. There are no penalties for multiple deliveries and they could be delivered at any valid time in the semester. To have access to a new handout, they must achieve success evaluation in the previous one.

Since the handouts are done in groups, a final project was designed to evaluate each student individually. In order to complete the final project successfully, students must have mastered the skills used in the handouts and must be able to apply them into an open project without the aid of his group. Thus, this component of the final grade is used to discourage free-riding (i.e. a situation where students do not contribute to the group's work but still earn a passing grade) and to encourage collaboration and engagement in the guides.

2.4 Feedbacks

During official class period during the semester, all groups or individuals have weekly short meetings to discuss about their performance in activities and project. The teachers are available for addressing doubts and issues, without interfering with the learning activities, just pointing out ways of researching the subject. In these weekly meetings, the groups are advised about their pace, comparing their performance with handouts expected duration. If necessary it is also given some advisory about the poor quality of the handouts.

The school schedule has two evaluation weeks per semester where each course must apply an evaluation activity. The intermediate evaluation in the exact middle of the semester and the final evaluation period occurs on the last week.

The intermediate evaluation is comprised of a 30 minute feedback meeting where students are encouraged to comment on their performance, their teamwork and their difficulties. If a particular group is not performing adequately, the instructor guides the students to diagnose their shortcomings and propose a solution to tackle them. Although the meeting's result is not a part of the final grade, the feedback can help students to improve their performance, which in turn is reflected on the grades.

The final evaluation is a one-on-one meeting focused on the final project. Students must be able to describe their solutions in both high-level and from a technical point of view. Special attention will be given to the way that the project accomplishes the non-functional requisites. The context of the solution developed in the project is not object of evaluation. There are some concerns and challenges about scalability of this model, discussed in session 3.1.

3 Results

In the discipline informal survey, 90% of the students reported that a main factor of motivation was that they were working with real hardware and not with theoretical problems or virtual environments (although most of the time they were really working on software or sysadmin terminal tasks). Besides considering that most of network activities were in a virtual environment, they felt more engaged by working with real equipment in a short time of period.

Also 90% of the students reported they sensed that the short lectures helped to complement their knowledge or to accomplish a research for some task in a handout. Some of them presented a tendency of studying peripherals subjects, not covered in this course, as they were encouraged to make themselves a short lecture about what they were studying.

Figure 2 – One example of the difference between a preliminary question answer and its equivalent in the conclusion session. The text was transcribed and translated to English language.

Preliminary Questions:

1. What is Juju and what is its role?
   "Juju is an open source tool for application modeling. Juju helps to deploy, configure, escalate and operate your application in public and private clouds"

Concluding:

1. What is Juju and what is its role?
   "Juju is a tool for application modeling. Its main focus is reducing the operation overload, facilitating deployment, configuration, scalability, integration and execution of operational tasks. It works integrated with several kinds of cloud services, public or private clouds, even with MaaS (Metal as a Service) and local Containers"

The handouts, as explained before, presented preliminary questions of key subjects in focus. It was really clear that all tasks inside the hand-out helped them to improve their knowledge. The evidence that supports this affirmation is in the quality of the answers of the same questions at the conclusion section, as showed in Figure 2.

The students unanimously pointed out that the opportunity for all groups work in their own pace, made them more self-motivated then traditional laboratory activities. As expected, more skilled groups sensed that they advanced faster than usual, as they felt motivated to go further and did not need to wait for the others. Surprisingly, no groups rushed trying to achieve the end of course before its official end date, but focusing in a better quality in activities execution.

3.1 Problems

Some groups procrastinated or did not have much discipline to organize their tasks and, consequently, got late in the schedule. Besides, when they finally achieved a passing grade (C - acceptable), there was not enough time left to improve their knowledge, and grading by consequence.

Other problem faced along the semester is the open source software dependency. All guides were designed and prototyped months before starting the semester, and they aren't immune to changes in the middle of the course. This issue was been minimized by having an alternative plan for the same task, most of them studied in the course design, but demoted by other better technique.

Needless to point out other recurring problems issued by the group activities model, like free riding or group conflicts, minored by group meetings during the week and the final individual project. Groups formed by 2 members had better proportional productivity and less conflict problems.

There is still a concern about the scalability, for example, if the discipline had the double of students. While a small group of 10-15 could be easily managed by 2 teachers, there are doubts about how many would be necessary for a larger group, with about 30 or 40 students. Hardware could be another point of attention, as the cost of the equipment will increase linearly too. Comparing to a traditional Computer Networks course, completely theoretical with lectures, only one teacher is necessary to manage a full classroom with no issues.

As pointed before, 2 members in each group seem to be the optimal formation, but the scalability constraints above must be observed. It showed to be possible to run with 3 students too, but some adjustment in the weekly meetings and a tightly tasks control would be necessary.

3.2 Students feedback and Design Review

In the official school discipline survey, students pointed out that the course was in line with their expectations, made compliments about the autonomously model and the practical handouts. Some concerns about infrastructure scalability were also mentioned.

In course design review, was decided to make some changes in next offering:

- The H1 will be redesigned to cover more Public Cloud technologies. The timeframe distribution will be also reformulated.
- The H4 Openstack distribution will be changed to a more stable version.
- The H6 will be mandatory. It was concluded that the container subject is too relevant to be optional.
- A penalty for a faulty handout delivery. It would mitigate the teachers work balance if some group just tries to play with the actual rules.
- All groups will be preferably formed by 2 members – this subject was already discussed before.
- The final project will also be remodeled, as some old requirements will be evaluated in the new H1.

4 Conclusion

This paper presented a remodelling of a Computer Networks course into a Cloud Computing framework. It showed the new subjects covered and how the old content was split into the program. It also resumed the content of the handouts and how the discipline was conducted.

Inside the structure of the discipline, it presented how activities were planned and executed, showing the expectation and results of each technique and how the issues were managed to be solved. Some interesting mechanisms to mention were timeless to completion handouts, wide open and knowledge measurement questions and student's short lectures. Other techniques like real practical activities, open project and self-learning researching have also been implemented.

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Project-Based Learning: development of PBL-based competencies under the pupil's perspective

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Abstract

Faced with a society driven by information and with the market expectations by engineers with key transversal teamwork skills, there is a demand for greater dynamism in learning and the vision of education as a process. The demand for changes in learning from education and the market results in the creation of new educational practices such as Project-Based Learning (PBL). In this way, the emergence of new education practices aims to a greater retention of knowledge in the long term and a greater attractiveness of the content studied by the discipline. The objective of this article therefore is to present an application of the PSP4 discipline in the context of the PBL approach under the lens of the knowledge spiral. This is an exploratory research through a case study. The object of study was the discipline Production Systems Project 4 (PSP4), discipline of the 7th period of the undergraduate course in production engineering at the University of Brasília. The results show that the PSP4 discipline fulfills the core principles of theoretical learning in project-based learning, driving knowledge retention from the use of more mechanisms and conversions of knowledge than traditional teaching. In comparison to traditional teaching-conversions from externalization and internalization, the PBL also presented mechanisms of the conversions from the socialization and combination, completing the knowledge spiral.

Keywords: Project-Based Learning; Project Management in Education; Engineering Education; Knowledge Conversions.

1 Introduction

Education is going through an emerging demand of changes facing the present transition from a written society to an information society. Thus, a greater dynamic of learning and the understanding of education as a process, centered on pupils, and not just as product, are required (Tavares & De Campos, 2014).

The origins of the project-based learning approach dates back to the first half of the 20th century, with the idea of active learning, initially developed by Dewey (1916) and by Kilpatrick (1921) (Lima, Da Silva, van Hattum-Janssen, Monteiro & De Souza, 2012; De Graaf & Kolmos, 2003). More significant and striking changes to the project-based approach, PBL, arise with the foundation of two Danish universities in the years 1970, University of Roskilde at 1972 and Aalborg University in 1974, based on new educational models oriented by Troubleshooting Principles (Kolmos, Fink & Krogh, 2004; Zhou, Chen & Luo, 2014).

PBL arises, therefore, as an approach in which the student is expected to create new materials, artifacts, processes and systems, with emphasis on the practical application of the theory through the implementation of projects, with the supervision of teachers (Tavares & De Campos, 2014; Reis, Barbalho & Zanette, 2017). Thus, it aims to provide greater interest in the studied discipline, knowledge retention and multidisciplinary training of students in order to solve real problems (Norman & Schmidt, 1992).

At the University of Brasília (UnB), the industrial engineering graduation course, consisting of 12 periods, is designed based on the implementation of eight projects using the educational practice of PBL. The course is structured with an imaginary line, observed in all periods, starting with introduction to the course, value formation in production systems, project methodology of production systems, PSP1, PSP2, PSP3, PSP4, PSP5, PSP6, PSP7 and PSP8. The first three subjects are the preparation of the students to start the projects, and all PSP's (Production System Project) correspond to PBL disciplines, with PSP3 and PSP8 optional for the students. Among these subjects, the course proposes complementary subjects to them. This proposal of the course increases curricular integration, assists the students for the professional market since the beginning and demonstrates the capabilities of the students.

The aim of this research is to present an application of a PBL discipline (PSP4) through the lens of the knowledge creation theory proposed by Nonaka & Takeuchi (1995) within the perspective of students who have experienced the discipline.

2 Production Systems Project 4

The curricular program of the industrial engineering graduation course at UnB is structured in a project-based learning approach. The production systems projects (PSPS) are disciplines from the 4th to the 10th semester that work based on four main anchors: (1) project methodology, (2) technical content of anchor discipline, (3) external partners linked to real problems, and (4) other disciplines with specific interests in the project (Aquere, Mesquita, Lima, Monteiro & Zindel, 2012; Zindel, Da Silva, De Souza, Simão & Monteiro, 2012; Barbalho, Reis, Bitencourt, Leão & Silva, 2017).

In this study, the discipline analyzed was PSP4, which consists of the elaboration of a project from knowledge developed in the discipline Production Planning and Control (PPC) - corequisite and anchor discipline of the 7th Semester (Barbalho, Reis, Bitencourt, Leão & Silva, 2017).

As brought up by Aquere et al. (2012) and Barbalho et al. (2017), the Project Management Process Model for Students Teams Coordinating in PSP4 was based in three stages: Preliminary project (PP), Intermediate project (IP) and Final project (FP) as featured in Figure 1.

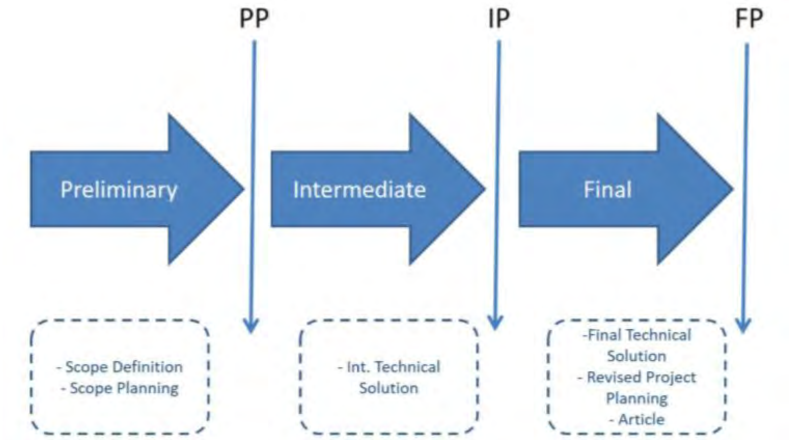

Figure 32. Basic structure of PSP4. Source: Barbalho et al. (2017)

This way, for the PP milestone, for example, the scope, schedule and management plans of Stakeholders, Communications and Risks are elaborated, providing a practical experience of the concepts brought by the PMBOK Guide (Project Management Institute, 2008). According to the analysis conducted in Barbalho et al. (2017), well-elaborated scope and risk analysis are the main directors of the performance of the projects regarding the final grades attributed.

The IP milestone, corresponded to the period that the team is responsible to make researches and apply the propositions of solutions decided in the PP, using and predicting the tools and risks already written in the project management plan. The FP milestone corresponds to the final step of the project. After implemented all the solutions it is improved and revised, then the final documents and articles are written and the project is concluded with the client.

Approximately 40 to 50 students, divided in 10 to 12 groups, compose the PSP4 subject. With two teachers, one from the main subject, PSP4, that is responsible to assist and evaluate the students projects, solutions and problems and the other form the anchor discipline (The PSP4 course is related to Production Planning and Control (PPC) discipline), which explains the possible solutions and takes out specific questions. The coordination of each group is the function of one of the group members, who is elected by their counterparts.

He or she will be the manager of the project, must guide the team, and be responsible to talk to the client, make the final decisions, look after the problems and write the management papers. The others will be responsible for the execution of the project.

3 Knowledge Creation Theory

According to the theory of creation of knowledge by Nonaka & Takeuchi (1995), considering that this is created through the interaction between tacit and explicit knowledge, there are four modes of conversion of knowledge (Figure 2). This way, the more stimulus there is in the four types of knowledge conversions, causing the spiral of knowledge to rotate, the greater the retention of knowledge, as expected of the PBL educational approach.

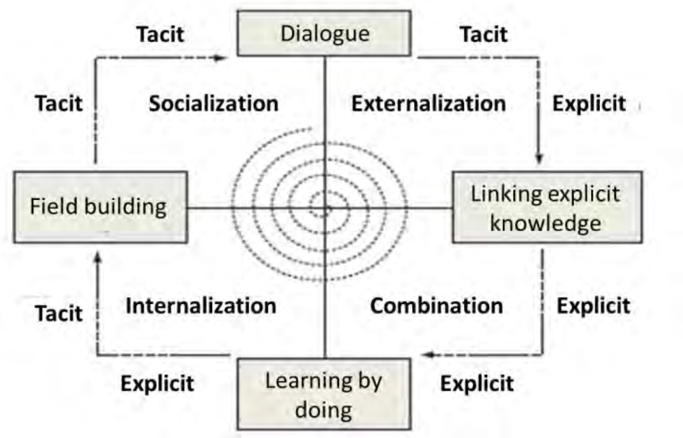

Figure 33. The For Knowledge Conversions.

Source: Adapted from Nonaka and Takeuchi (1995 *apud* JUNIOR et al., 2010)

Explicit knowledge is the formal knowledge, of course, and easy to be communicated. Tacit knowledge is the one inherent in the abilities acquired throughout the life of an individual, the one which is in the minds of people. The interaction of these two types of knowledge occurs through four conversions of knowledge as shown in Figure 2, according to Nonaka & Takeuchi (1995).

The socialization consists of the interaction between tacit knowledge and is generally made through dialogue. By transforming tacit knowledge into explicit, through externalization, there is a linking of different knowledge. The interaction between explicit knowledge is named as combination and it results in learning by doing it - the basic premise of PBL learning. Finally, the conversion of explicit knowledge into tacit knowledge through the internalization results in the construction of new knowledge fields (Nonaka & Takeuchi, 1995).

4 Methodology

The present study is an exploratory survey through case study (Yin, 2011), based on the pupil's perspective on their experience in a project conducted in a PBL discipline. Under the team project’s lens, features and key skills developed during the semester were listed considering the timeline of the PSP4 discipline according to existing formal evaluations - PP, IP and FP. In this way, the study aims to observe aspects of PBL foreseen in literature and found in the course of the discipline and events that favored the construction and retention of knowledge throughout the project from the knowledge conversions defined by Nonaka & Takeuchi (1995).

5 Case Study

5.1 PSP4 Discipline and the Knowledge Spirals

By observing traditional teaching, it is perceived that, majorly, only the internalization – passive receiving of information in the classroom – and the externalization – exposure of knowledge acquired in trials and evaluations – are activated within the knowledge spiral.

This work discusses the spiral of knowledge in the PBL approach implemented in the PSP4 discipline. Thus, the following methodological elements are used in the discipline, considering the spiral of knowledge of Nonaka & Takeuschi (1995): Socialization – most of the face-to-face encounters between pupils and teachers in discipline are directed to take doubts about the ongoing projects and the theory used for this, as well as for pupils to interact in achieving the goals of the project; Externalization – There is no evidence on the technical content of projects through trials, but students must deliver presentations at each stage of the project (PP, IP and FP), in addition to a project management plan in step PP, a written summary with technical work carried out and a scientific article under the project in the FP step; Internalization – In the light of deliveries, students must study various contents that allow to carry out the planned deliveries; and Combination – it is very common that projects require the combination of knowledge of different areas. Minimally, the discipline demands that project management and production planning and control concepts are combined in the planned deliveries.

5.2 Project Developed in Discipline

The project consisted of the application of forecasting demand methods – simple linear regression, simple moving average, weighted moving average, simple exponential smoothing and double exponential smoothing – at a retail pharmacy in order to identify and understand the sales behaviour for different products and build a forecaster model closer to the one exerted by the company and which could be used by it. As defined in the PP and from the bibliographical research conducted, to develop the study it was necessary to gather information through open interviews with employees and one of the partners of the store. Additionally, after an in-locus research and identification of data sources for analysis, information was collected through reports made available in the company's management system with sales data for a three-year period.

In this way, the ABC curves of the products were elaborated from their profitability and sales volume in order to prioritize the products to be studied under the demand management point of view (Chen, 2008). Subsequently, the behaviour of the demand for the chosen products was analysed in order to identify characteristics of the seasonality and the trend of these, to base the choice of the most appropriate prediction method.

With the application of the proposed forecasting methods, the forecast templates elaborated for the products were analysed and compared to find the method that best suited each one. The comparison was made in two ways: (1) verification of errors encountered in prediction – percentage adjustment, relative error and error quadratic; (2) graphical analysis to check the adhesion of the data.

5.3 Learning Experience

The implementation of the project, the activities envisaged in a general way and situations arising therefrom, unfolded in a way that put the team at times when it is necessary more than the technical knowledge learned from the anchor discipline. With this, skills inherent in the PBL were developed, such as leadership, motivation, communication, decision-making, negotiation and management of conflicts, as well as skills more linked to the concepts of PPC and project management.

Within this perspective, a list of 32 competences was elaborated from the literature (Table 1) covering aspects of PBL, project management and PPC, and according to the perspective and experience of the authors themselves in the development of the project. The competences were allocated into three groups: (1) Soft Skills - skills developed from personal aspects which generally come from experience; (2) Management - management capabilities, organization and administration, for example; (3) Technical - specific knowledge related to the anchor discipline. The junction of these features produces a greater effect for long-term knowledge retention and a greater appeal for the content studied in the discipline (Norman & Schmidt, 1992).

Table 16. List of 32 competences evaluated in the study.

Management		Soft Skills		Technical
1. Schedule Formulation 2. Scope Definition 3. Work Breakdown Structure (WBS) Preparation 4. Stakeholder Identification 5. Stakeholder Analysis (expectations, power and interest) 6. Development of Communication Artefacts	7. Risk Analysis 8. Strategic Thought 9. Monitoring and Control of Project Indicators 10. Monitoring and Control of Deliveries 11. Political and Cultural Knowledge 12. Result Orientation	13. Communication 14. Formal Presentation 15. Building Trust in the Team 16. Conflict Management 17. Troubleshooting 18. Relationship Building 19. Self-Management 20. Self Confidence	21. Collaboration 22. Creativity 23. Proactivity 24. Leadership 25. Negotiation 26. Team Work 27. Ethics and Values 28. Adaptability	29. Inventory Data Analysis 30. ABC Curve 31. Demand Forecast 32. Process Flowchart

Source: Adapted from Bezerra, Costa& Riffel (2010); Taajamaa, et al. (2013); Aquere et al. (2012); Dym, Agonino, Eris, Frey & Leifer (2005); Coyle, Jamieson & Oakes, (2005); Project Management Institute (2008); Fernandes & Godinho Filho (2010); and Kumar & Hsiao (2007).

Each competence was evaluated by each member of the team aiming at establishing at what phase (PP, IP or FP) and in which degree each one was developed and was more intense, being awarded a score based on the Likert scale of 5 points, from 1 to 5. All the members evaluated each competence, from 1 to 5, making an average of those grades. Next, they were summed up according to the respective group of each competence. These numbers were used to make a percentage, which was used to make the following graph. The result is in Figure 3. Competences can be present in more than one moment and have the same intensity level or not.

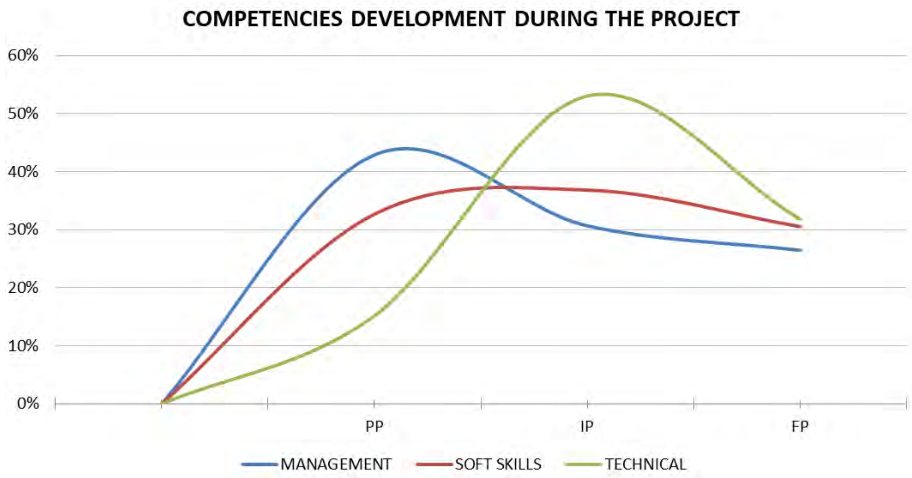

Figure 34. Graph of competences development in the course of the project. Source: The authors (2018)

Other two analysis were made with the data used to build the graph. The first one aimed to analyse the difference of grades each member attributed to the competences. It was calculated the standard deviation of the sum of the grades each member gave to the competences from each group, differenced by PP, IP and FP. Consequently for each group were calculated three standard deviations. The group of competencies that obtained the biggest difference - all standard deviations were high - was the soft skills, with 6,45 for the PP, 4,55 for IP and 16,64 for FP. The group that had the minor difference was technical, with 1,41 for PP, 0,58 for IP and 3,11 for FP. The other group, management, had a more constant deviation varying from 3,0 for PP, 3,86 for IP and 9,06 for FP.

The second analyse made aimed to see if the difference among the competences of each group were significant. It was made by the sum of the average of the grades in PP, IP and FP, of each competence in each group, then, calculating the standard deviation of these numbers in each group. It was observed that among the related competences there was none that stood out, having a standard deviation of 1,72 among the management competences, 1,14 among the soft skills competences and 1,52 among the technical competences. These numbers show that the difference between the competences is not significant, and that the first, management, probably has the biggest difference since the perception of management skills vary from each member and function.

Figure 3 represents the particularities in the development of competence groups in the course of the project, we can perceive that the management skills curve presents its apex during the PP, indicating that there has been a greater managerial focus related to initiation and planning at the beginning of the project. This moment was also marked by combining different sources of information, joining different forms of explicit knowledge. Then the curve suffers a fall in the intermediate project, which remains in FP, representing a similar effort in the stages of execution, monitoring and closure.

The curve related to technical competence has a low percentage at the beginning of the project, however it begins to grow in the transition between PP and IP, moment marked by the study of tools that will be used in the project. This learning takes place on the student's own account, by the internalization that occurs by the pupil when learning the necessary content in the lessons of the anchor discipline, also by socialization among the group. This curve reaches its apex in the IP, demonstrating the technical development that occurs during the intermediate step of the project, marked by the focus on the application of the tools used to analyze the company's data and processes.

Finally, when analysing the perspective of the soft skills curve, we perceive the importance of project based learning in relation to these competences. The curve, as it can be seen in Figure 3, remains more constant than the other curves, showing that skills related to soft skills, such as negotiation and teamwork, are worked and developed in a similar way throughout the project.

Based on the analysis of competences along the stages of the project it was possible to identify the four types of knowledge conversions proposed by Nonaka & Takeuchi (1995) at each stage. During the case study, several reinforcements were identified in each type of conversion – socialization, externalization, combination and internalization (Figure 2) – as it can be seen on Table 2.

Table 17. The four knowledge conversions by Nonaka & Takeuchi (1995) applied to the learning process in a case study of PSP4.

Socialization	Externalization	Combination	Internalization
Group discussion	Project presentation in the three phases	Tools application	Methodology studies
Discussion with advisor	Elaboration of reports and management plans	Use of knowledge obtained in diferent disciplines	Anchor discipline classes
Discussion between diferent project groups	Tools elaboration	Academic articles writting	Articles reading

Source: The authors (2018)

From the development of Table 2, it became possible to visualize more clearly how the four conversions of knowledge were approached during the process. Moreover, the same conversions were crossed with the phases of the project through the competences analyzed in Figure 3, thus aiming to define in which stages – PP, IP or FP – there was a greater performance of each of the conversions. As Figure 4 shows, the four conversions are very similar in all stages of the project. With this in mind, it can be said that the spiral of knowledge rotated uniformly throughout the project.

The following graphs were obtained by the attribution of grades from 1 to 5, using the Likert scale, by each member of the group, to each competence, in each moment - PP, IP and FP. The grades given were summed up in each group of competences. Next, they were grouped in PP, IP and FP, adding all the grades from each member to each group of competences. Finally, it was made a percentage of each group of competences developed in each moment of the project.

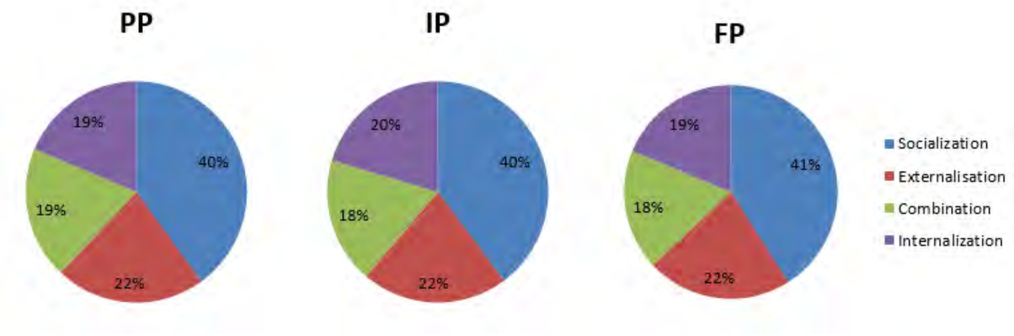

Figure 35. Graph of knowledge conversions at each stage of the project. Source: The authors (2018)

Considering a subjective perspective of students and the inputs of Table 2 and Figure 4, it was possible to conclude that, socialization and externalization were highly present during all 3 stages of the project, through the presentations in class and to the customer, as well as the exchange of experiences between members of the group and among teams, highlighting the transformation of tacit knowledge into explicit, and vice versa. The combination was more present in the intermediate project, in which thanks to the meetings, documents, reading of articles and conversations, the amount of information on the subject discussed and the work that was being carried out, enabled the application of what had been discovered and the documentation of this information. Finally, the internalization was present throughout the whole project; however, it stood out in the preliminary project and in the intermediate, as those were the moments in which the team was most needed to seek training and new knowledge in an autonomous manner.

This is a significant gain of reinforcements in the cycle compared to the traditional education, which in a majority way presents only the activation of the internalization – passive receiving of information in the classroom – and the externalization – exposure of the knowledge acquired in evidence and evaluations – within the knowledge spiral.

6 Conclusion

This study aimed to present an experience from the student's point of view of the PSP4 discipline, in the context of the PBL approach through the lens of the knowledge spiral proposed by Nonaka & Takeuchi (1995). It can be noted that the PSP4 discipline, within the case study conducted, meets the central principles of problem-based and project focused learning. In comparison to traditional education – which has conversions of knowledge from internalization and externalization, the PBL in this study, also presented conversions from the socialization and combination, complying with knowledge creation theory proposed by Nonaka & Takeuchi (1995). Moreover, all four conversions happen in all stages of the project helping to enable greater and better assimilation of the content addressed. The graphs presented on Figure 4 suggest the spiral of knowledge rotate uniformly in all the phases of the project.

Highlighting the assertion above, the study of a list of 32 competencies (Table 1) that were developed by students during the project experience. These features allocated in three macro groups prove the diversity of competences that works under this method of teaching. The competence groups were analyzed according to the course of the project, being the management skills with their apex in the Preliminary Project, the soft skills were virtually constant throughout the project and the technique with the apex in the Intermediate Project.

A multidisciplinary approach as here discussed has a consequence of training students not only on technical subjects. In real world, alumni will deal concurrently with technical, managerial and behavioural challenges. Future research can evaluate levels of problem solving competences in groups with and without the kind of training here presented.

The largest limitation of the study was the identification of existing knowledge conversions based only on the experience of one of the projects developed during the semester under a PBL approach up to ten ran out. In this way, it is suggested as a future work a comparison with the results obtained in this survey with results in a larger sample of projects and subjects within the curricular program of undergraduate production engineering of UnB and other curricular programs based on project based learning.

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Disassembling Computer Engineering Education

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Abstract

Computer Engineering programs are relatively new when compared to more traditional Engineering fields and, in fact, were often conceived in Electrical Engineering or Computer Science departments. As a consequence, Computer Engineering programs tend to acquire an identity that resembles a mix of ideas from its parent departments. While this is understandable, given how fast the field evolves, there is a need to establish its own clear identity. A starting point to define the identity of a Computer Engineering program can be, since it is a professional higher education degree, the requirement that it adequately prepares students for a professional life. Content and skills deemed necessary for a successful Computer Engineer must be ascertained in collaboration with industry and academia representatives. Furthermore, this design effort must consider both current and future needs, in order to have a lasting impact. In this paper, we report on our recent experience of designing a new Computer Engineering program. In order to identify what are the main competences that a Computer Engineer should have, we conducted interviews with industry leaders, and analyses on technology perspectives. We observed that Design and Entrepreneurship are considered fundamental abilities of a modern Computer Engineer and non-cognitive skills, such as teamwork and self-directed learning, are identified as key dimensions for a successful professional. Courses were organized towards the development of competences, rather than partitioned by technical content, focusing on creativity, hands-on experience, and problem solving. Multidisciplinarity is a natural consequence of this approach, as many real problems cannot be solved by the application of knowledge from a single discipline. As a result, the content present in traditional courses is distributed across the curriculum - a challenging proposition, which demanded strong integration between faculty members.

Keywords: Computer Engineering; Curriculum design; Hands-on experience; Problem solving; Multidisciplinarity.

1 Introduction

There is an increase in demand for computer engineers in industry. The field of Computer Engineering figures among those with the highest paid salaries (Dill, 2016), and the most promising hiring perspectives for new graduates in the near future (Strauss, 2016). This is a relatively new field of engineering, and the challenges faced in the domain of Computer Engineering soon made evident the need to better characterize the field; hence, the structure of Computer Engineering degrees has been a subject of study by professional and academic associations, with the goal of promoting more effective education and yielding better professionals. The Joint Task Group on Computer Engineering Curricula ACM/IEEE (Impagliazzo et al, 2016) defines Computer Engineering as:

> *"Computer Engineering is a discipline that embodies the science and technology of design, construction, implementation, and maintenance of software and hardware components of modern computing systems and computer-controlled equipment."*

The preceding definition of Computer Engineering shares a trait with all Engineerings: the concern with practical applications. Tracing the lineage of most Engineering fields leads to its origins in Military Engineering (Tadmor, 2006), which by necessity has a highly practical bias. In the first half of the twentieth century, there has been a migration in the mindset of Engineering schools towards its establishment as a science, searching for solid scientific foundations (Tadmor, 2006, Prados et al. 2005 apud Lattuca et al., 2006). This "science revolution" in Engineering resulted in a diminished role for practical applications and engineering design in the various engineering curricula. According to Tadmor (2006):

> *"An inevitable byproduct of the science revolution was that engineering design, because it did not have a formalized, quantitative, teachable core body of knowledge, was largely eliminated from engineering*

curricula. Instead, engineers were expected to learn design on the job. Indeed, the development of a formalized approach to engineering design remains an open challenge to the engineering professoriate."

Although Computer Engineering programs are new, they emerged from established fields and most of them inherit the same inclination towards teaching extensively Mathematics and Physics. Furthermore, topics that are more technological than scientific are still approached with the same method as the more scientific items, even if it would be more beneficial to other stakeholders (students, industry, society) to give the teaching of technological issues a more practical inclination.

This approach to the teaching of Engineering in general, and Computer Engineering in particular, resulted in a situation where Engineering degrees are not fulfilling their original mission of producing effective engineering professionals. According to a report by The Institution of Engineering and Technology (IET) in the UK (Fine & Perkins, 2016), about 62% of the surveyed employers agree that "a typical [graduate] recruit to an engineering, IT or technical role does not meet [the employer's] reasonable expectation". When inquired about which competencies were missing for the recent graduate cohort, the highest reported items were: the lack of practical experience, business acumen, leadership and management skills. Asked in a multiple-response survey about the role of technical degrees and why they do not suit requirements from industry, 59% reported that practical skills are not developed, 43% complained that technical degrees do not provide opportunities for students to acquire practical work experience, and 39% argued that courses are not kept up-to-date with current practices and technologies in industry. This demand for producing graduates that are more practically-oriented does not preclude the role that employers must have in helping to transition students into the workforce: 97% of respondents agreed to this responsibility, and 91% believe that they should offer apprenticeship to students.

As a consequence of the dynamism that characterizes all Engineering fields, and the pressure to adapt to the new reality of society and industry, Engineering education as a whole has been undergoing a major change in the past century (Froyd, 2012). It is recognized that the competencies of a successful computer engineer must go beyond pure scientific and technical knowledge.

In summary, it is desired that a Computer Engineering program should be fast to adapt to the rapidly evolving field, and that a stronger connection between schools and industry must be made in order to lead students into becoming effective professionals. In this paper we describe our experience in designing a new Computer Engineering program at Insper college. The paper is organized as follows: Section 2 presents some related work in national and international scope. Section 3 details reasons and strategies for creating a new computer engineering curriculum. Section 4 shows results with disciplines created, and section 5 closes with some conclusions.

2 Related Work

In this section, we describe international and national references of innovative Engineering programs that were specifically designed to address some or all of the aforementioned issues. We did not restrict the review to Computer Engineering programs, as several of the issues are shared by Engineering programs as a whole, but we did feel the need to separate international from national, as the latter represents a better reference for the specific restrictions of the Brazilian context.

2.1 International references

A notable reference in this review is the Franklin W. Olin College of Engineering in Needham, USA, whose curriculum has a strong emphasis on design, teamwork, entrepreneurship, transdisciplinarity, learner autonomy, and Project-Based Learning (Somerville et al., 2005). Because of the effectiveness of this approach, confirmed by the successful placement of graduates in the industry, a partnership with Olin for training and consulting during the first years of the program was established for the development of the program presented here.

Other references were also considered in order to achieve the most adequate curriculum possible. Of particular interest is the Engineering Clinic of the Harvey Mudd College, Claremont, USA, an experience inspired by clinical practice of medical schools that brings together juniors and seniors, coached by faculty members, to solve real problems from the public and private sectors (Bright & Phillips, 1999). The success of this initiative was confirmed by industry surveys, being a strong example of the professional alignment we want to achieve.

Another reference is the Aalto University in Helsinki, Finland. (2017). This institution was established by merging three universities: the Helsinki University of Technology, the Helsinki School of Economics and the University of Art and Design of Helsinki. The merger was specifically designed to foster innovation through the collaboration of science, business, and art, making it a remarkable example of transdisciplinarity as the backbone of a program.

2.2 National references

The Biomedical Engineering program of the Pontifical Catholic University of São Paulo (PUC-SP) has an example of curriculum designed from scratch with professional alignment in mind (de Campos et al., 2009; Lima & Guimarães, 2012). This program is based on Problem-Based Learning distributed along two dimensions: axes and modules. An axis represents one of five main sets of abilities and competences. A module represents a set of theoretical and practical activities designed to support the solving process of a closed problem that requires abilities and competences from all axes. There are five modules, each lasting one year and gradually increasing in complexity.

In contrast, the Production Engineering program of the University of Brasilia (UnB) has an example of curriculum that already existed but was significantly redesigned. (da Silva et al., 2016; Monteiro et al, 2016). This program is based on special courses called Production Systems Projects (PSPs). On each PSP, the students design and implement a project that requires knowledge from previous periods, while also learning aspects of synthesis, integration and entrepreneurship in the process. The main difference between a PUC-SP module and a UnB PSP is that the former is based on a closed problem and the latter is based on an open project. In order to ensure that the project does in fact require knowledge from previous periods, its scope is guided by a faculty member. It should be emphasized that this faculty member does not impose a specific scope, but rather coaches the students while trying to keep as much autonomy as possible.

Finally, the Lorena Engineering School of University of São Paulo (Pereira, 2015; Pereira & Barreto, 2016) has an example of curriculum that is gradually migrating from a traditional lecture-based model to a Project-Based Learning model. This migration started with a single course, Introduction to Industrial Engineering for the first semester, and due to its success it is currently represented by three courses: Integrated Project I in Industrial Engineering for the first semester, Integrated Project II in Industrial Engineering for the fourth semester, and Integrated Project III in Industrial Engineering for the seventh semester. These courses are similar to UnB PSPs, in the sense the faculty members coach students while trying to keep as much autonomy as possible, but with an important difference: the project requires knowledge from the current period. This makes the process closer to the pure definition of Project-Based Learning, instead of being an hybrid model that mixes application and learning.

3 Designing a New Computer Engineering Program

The *raison d'être* of a Computer Engineering program is to educate students that will be effective members of society in their roles as Computer Engineers in industry, academia, government, or in the third sector. Starting from this perspective, we initiated the process of designing our new program. We needed to identify the stakeholders in this context, their roles, goals, requirements and motivations. From this analysis of requirements we could structure the main objectives of the program, and the main lines of action towards fulfilling these targets. Once delineated, the detailed specification of the program was constructed.

3.1 Stakeholders

A stakeholder is "any group or individual who can affect, or be affected by, the achievements of an organization's purpose" (Freeman, R. E. (1984) apud Miles, S., (2017)). We identified as stakeholders to a Computer Engineering program the following agents: students; industry; society, including the regulatory agencies; and academia.

3.1.1 Students

Students are one of the primary stakeholders of a Computer Engineering program. They invest time and money into the program, and expect to become effective professionals at the end of their degree. Students may enter the workforce in positions in industry, academia, public sector, or third-sector, and the Computer Engineering program has to consider these career possibilities on behalf of the students. But in whichever sector the students endeavor, a commitment to foster practical applications of science is the hallmark of the engineer: as shown in the aforementioned IET report (Fine & Perkins, 2016), it is important that technical degrees present the practical design aspects that characterize the field, alongside the fundamental theory. This determination serves to prepare the students for an effective participation in society now and in the future.

3.1.2 Industry

During the development of the curriculum, some companies were consulted on what technical and non-technical skills are expected for a computer engineer. This query led to the identification of a series of skills that served to map the disciplines of the Computer Engineering course.

A total of nine organizations from different areas were interviewed throughout 2014. Organizations focused on two points: in the technical side, they focused in software quality; and in the non-technical dimension, the recommendations were oriented towards more effective communication. It is clear from the interviews that developers should create software with higher quality, compliant with specification, being stable, robust and with easy maintainability. On the other side, communication was a problem detected with current engineers which is limiting the efficiency of larger teams and, consequently, complex products.

Data science and big data skills were deemed necessary for the challenges and opportunities appearing in a near future. Embedded systems, together with Internet of Things, are other points constantly reinforced. The shift towards a cloud based architecture was also a common description of competences needed for the future engineer.

3.1.3 Society and Regulatory agencies

Similarly to other Engineering disciplines, Computer Engineering programs are subject to regulatory concerns, which reflect the requirements society presents to the future professional computer engineer. Higher education approvals and evaluations are conducted by the Brazilian Ministry of Education (MEC) through the INEP (National Institute of Studies and Research), which evaluates the programs documentations and perform visits. The CONFEA/CREA system controls the exercise of the engineer's profession, originally (1933) set by the Regional Engineering, Architecture and Agronomy Council (CREA), and later (1966) reformulated by the Federal Engineering, Architecture and Agronomy Council (CONFEA), the central organ of the system which regulates the profession nationally.

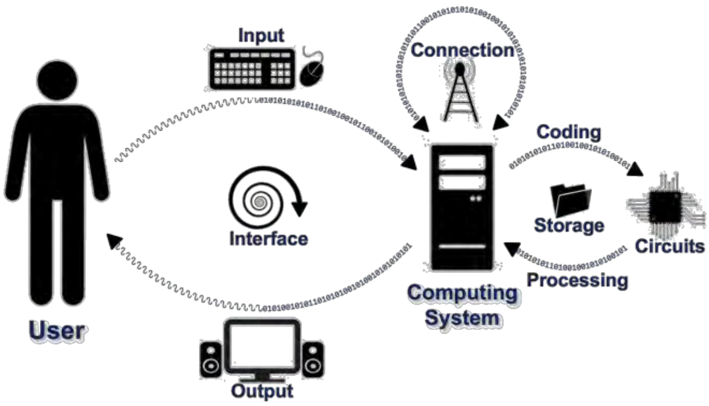
3.1.4 Academia

Computer Engineering, as an academic discipline, is a thriving area of innovation and of fundamental discoveries. The developments in this field push forward the Third Industrial Revolution (Liu & Grusky, 2013), through the creation of novel technologies and ideas that are transformed into goods and services by industry. It is important that those alumni of Computer Engineering programs that are inclined towards academic work are adequately prepared to attend Graduate School.

3.2 Computer Engineering Framework

A Computer Engineering framework (Figure 1) was created to help defining main goals of the Computer Engineer program. Specifying the main goals to achieve helped to map course programmatic outcomes. This framework was defined with the feedback from all stakeholders that supported the effort of developing the new curriculum.

Figure 1. Computer Engineering Framework.



The framework shows how the main components are connected. Each component is better detailed below:

Interface: Computer system inputs and outputs must be dealt together. This whole process can be called interface, and directly influences the quality perception of the system. Students should take care of the experience of their users.

Coding: Computer engineers should be able to translate their intentions into an appropriate programming language, from low to high level. They also have to know the formalities required to solve problems with good practices to generate code capable of being shared and maintained.

Circuits: Code must run on specific hardware and, depending on the problem, one architecture may be better than another. It may even be necessary to develop or customize new computer architectures. Computer engineers must balance between software and hardware approaches.

Processing: All information at some point goes through processing, and the computer engineer must know how to create efficient routines that are able to get results from complex data structures into something valuable.

Storage: Modern applications often work with large data streams. The different types of information have very different requirements of access time, perenniality and security. Computer engineers need to know how to design the best data storage solution for each type of application.

Connection: Computing systems are now all connected in some way, which can range from a direct physical connection among devices to complete cloud solutions providing important computing resources and services.

3.3 Mapping competences

Table 1. was created to identify the main topics in relationship with the computer engineering framework. This table was created based on the competences identified by academia, other organizations, undergrad students from other programs.

Table 1. Computer Engineering Identified Topics.

Area	General Skill
Interface	Computer Usage; Render Information; User Interface Dev.; Design; Human Interaction; Interaction Devices
Coding	Software Development; Software Optimization; Agile software development; Software Engineering
Circuits	Architecture Handling; Architecture Evaluation; Control and Automation Dev.; Custom Design System
Connection	Interconnect Computers; Interconnect Applications; Servers; Data Center Projecting; Custom Connections
Processing	Encoding Information; Embedded Software; Computer Simulation; Signal Processing; Data Analyzing;
Storage	Organize Information; Storing Information; Web Information

These topics were further detailed, and typical experiences were defined based on Basic, Intermediate and Advanced levels. The strategy was to define the proficiency expected in each of the specific levels. Table 2 shows some table rows, from a complete table with more than 100 specific skills specified.

Table 2. Sample of Specific Skills and Experience Levels.

Specific Skill	Basic Level	Intermediate Level	Advanced Level
Unix Usage	manipulate files in a shell unix	develop shell scripts	stream editing with data pipes
Operating System	install a windows and linux OS	checking drivers consistency	starting and stopping services
Computer Drawing	draw vector images (SVG)	draw 2D sprites	3D modeling and animation
Sound Synthesis	simulate a piano	use human speech synthesis	simulated 3D spatial sound
Web Development	web site with HTML5 and CSS	develop a portal with AJAX	write a server-sent event
Graphical interface	data graph analysis	draw in native interfaces	multi-touch user interface
Hardware display	light LEDs randomly	graphical LCD display texting	perform a projection mapping
Software quality	include error management code	add error handling mechanism	code thread safe routines
Data centers	remote access a server	automatic reinstalling a cluster	keep system always available

3.4 Semester Thematic

In order to improve collaboration among disciplines, each semester was organized around a central thematic. Themes could help faculty to find common points and allow them to propose complementary teaching activities.

The overall theme of the first four semesters was "human-centered computing". The first four semesters are mostly focused on designing for better user experiences. Human-centered computing generally involves some of the following disciplines: human factors, sociology, psychology, cognitive science, anthropology, communication studies, graphic design, science and technology studies, industrial design and several other areas of computer science. By the end of these semesters students should be able to: Identify user needs; Encode and debug computer programs; Observe a problem and develop the heuristic to solve it, translating into a computer program; Develop graphical user interfaces for mobile users.

The theme of the fifth semester is related to Ubiquitous Computing, a tendency for resources to be no longer concentrated in one location but accessible anywhere. Members of a development team are often in distant countries; servers are virtualized in remote locations; the access interfaces are constantly evolving to web pages; computers are optimized by reducing size, computing resources and cost of the product to be embedded in objects and scattered around the world. By the end of this semester students should be able to: Plan and manage software and hardware development teams; Assemble and maintain main computing components, such as service servers; Develop web systems; Understand the logic of operation of the main digital electronic elements.

The theme of the sixth semester is related to Systems integration, in other words, the integration of the different areas of computing for the development of products that suit the users better. This integration involves areas such as artificial intelligence, database, computer graphics, software engineering, computer networks, sensors and actuators, among others. Allied to this is the need efficient communication of these technologies in order to create a better experience for the users. By the end of this semester students should be able to: Combine software and hardware technologies against a goal; To be able to work with a database of several sizes; Develop digital games; Use computer resources to perceive the environment and to act in some way.

The theme of the seventh semester is about Critical Computing. It deals with critical situations where there is a greater demand for performance, such as robust algorithms capable of blocking unauthorized access, development of computer systems to perform several calculations simultaneously, interactions with virtual systems for a better understanding of a problem, specific hardware development for problems where traditional solutions are not enough. By the end of this semester students should be able to: Recognize system vulnerabilities and optimize solutions; Parallelize and distribute code in supercomputing architectures; Create systems for interactions with users more efficiently; Develop hardware for specific applications.

3.5 Competences Balance

The developed engineering program was conceived to focus in some competences: Technical Skills, Context Awareness, Interpersonal skills, Entrepreneurship, Design and Learning to Learn. These competences should have a minimum time dedicated by students in order that they really acquire and develop the competences. It was expected around 10% of each competence being developed at classroom for each competence, to achieve this courses were organized in a way that each one should cover some competences intentionally, and at the end, the sum of the competences in the entire programs should be consistent with the planned mission of a strong focus on maturity of competences by students.

3.6 Preparing Faculty

Traditionally, good technical and academic credentials are the main hiring requirement of faculty members for a higher education program in Engineering. This is a necessity, given that faculty must be up-to-date with the latest advances in their field in order to design curricula that will best serve the needs of all stakeholders, especially the students. Unfortunately, this manner of hiring often diminishes the importance of good teaching skills. In fact, Ambrose and Norman (2006) note that: "When engineering faculty members enter the academy, many—through no fault of their own—are not fully prepared for their role as educators." We approach this problem through the training of all new faculty, which are often hired early in order to attend courses on best educational practices, and through mentoring by more senior faculty members.

4 Results

Below is a list of the courses developed specifically for the Computer Engineering Major. The implementation of this course is part of an undergrad program oriented for a hands-on experience in project based learning (Soares, Achurra, & Orfali, 2016). The computer engineering program consists of general courses, but these details are out the scope of this publication.

Software Design: The objectives of the course are to enable students to code and debug computer programs individually and in groups, identifying user needs, and developing heuristics to address the functional and nonfunctional requirements of a program. Students will work on general software development projects individually and in group. Software project management techniques are practiced during the course.

Elements of Systems: With the increasing complexity of computer technology and the knowledge-based specialization, students suffer to understand how a computer works in its details. This course will give students an practical experience in the several layers used to make a computer to run. Students will build a computer from transistors to operation system routines gradually.

Agile Collaborative Development: This course will leave students immersed in a professional developer environment, where it will be necessary to make decisions on how to conduct a software project in a team. Students will deepen in an object-oriented language generating more efficient and reusable codes.

Computational Robotics: Robots are systems that need to operate safely in a physical world amid human beings and diverse constraints. This course allows students to become familiar with various techniques of intensive robotics computing (machine learning, pattern classification, computer vision, planners, cognitive architecture) and apply them in the context of a practical project in robotics.

Web Technologies: In this course students will be able to create dynamic pages, with a strong observation in the user experience. Students will learn how to develop multilayer pages and use features to make them dynamic.

Logic of Computing: This course presents, in a contextualized way, several advanced concepts of computation and programming that require a certain maturity and previous experience in the area, established through relation with previous disciplines.

Embedded Computing: The course covers hardware and software involved in embedded systems. A special emphasis will be placed on connecting day-to-day items to large databases and networks, integrating the physical world with the digital world through the web, known as "Internet of Things".

Social Networks: The Social Networks discipline studies the transposition of social issues to the digital medium from the increase in Internet penetration. It investigates how computing can be applied to understand social phenomena and what conclusions can be drawn from social graph analysis.

Cloud Computing: New paradigms of personal computing have led to the processing and storage of information from the local computer to the Internet. Student will be able to create a cloud services environment by designing services, preparing computers and configuring them to provide these services.

Computer Design: This course explores the fundamental principles of modern computing systems, focusing on the critical role of performance in designing computer systems. Students will be able to develop circuit designs and can actually build their own microprocessor based on reconfigurable architectures.

Hacker Technologies: Hacker is a person who likes to explore the limits of computing by challenging himself, exploiting access to computers. In this course students will learn about the main security systems and their vulnerability points. How current networks control access to people and what ethical issues are involved.

Supercomputing: Many computational problems in engineering require computational resources that go far beyond what is available in traditional computers, often rendering the solution unfeasible. In this course students will develop supercomputing systems, identifying best technique regarding, cost of operation, and availability.

Digital Games: The development of digital games involves a great deal of competence in various computer and mathematics skills. In this course students will have to integrate techniques of computer graphics, artificial intelligence, human-computer interaction and data structure.

5 Conclusions

Computer Engineering is a complex field in constant evolution. While efficient pedagogical paradigms have been available for decades, they are not extensively used in Engineering. There is a need, by society and industry, to have engineers with better professional competences. These were some of the reasons that justified the creation of an entire new curriculum for a computer engineering program. Some of the important decisions that were made through the design of the new program concerned its focus, and which competences a student should acquire. The competences of design, entrepreneurship, self-directed learning, context awareness, and interpersonal skills, were selected as the most important for a computer engineer. Courses were organized in thematic by semester, and aimed to a practical experience, that leads to a theoretical understanding of the problems.

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From Design Thinking to Front-End Development: Applying a Set of Course Principles over its Own Redesign

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Abstract

Traditional Engineering curricula do not include Design Thinking content in mandatory courses. Therefore, this content often faces strong resistance when offered in a modern curriculum, due to not being seen as part of the commonly accepted definition of an Engineer. Pushing a cultural shift or building an admission process that minimizes such resistance would be effective solutions, but are too slow to be implemented in the short term.

On the other hand, there has been an increase on the importance of Computer Programming, particularly Front-End Development, in both Engineering and Design professions, regardless of their specific fields. In the case of Engineering, even fields that are not traditionally associated with computing, like Mechanical Engineering, are demanding a minimum of programming skills. In the case of Design, it gained popularity as a tool for digital prototyping and portfolio building.

In this paper, we describe the design and implementation of the Co-Design of Applications course, offered to second semester students of a Mechanical, Mechatronics, and Computer Engineering common curriculum. Its learning goals are: analysing users from interviews and hypotheses, synthesizing project questions from user analysis, creating mobile application concepts from project questions, evaluating mobile digital prototypes from personas and scenarios, and applying graphic design tools and web front-end technologies in digital prototyping. The last goal did not belong to the first version of the course, and was deliberately included in the second version to reduce the aforementioned resistance to Design Thinking content.

The main insight for redesigning the course between the two versions was using Front-End Development, a demand from both the Engineering and Design industries, to bridge the gap between the commonly accepted definition of an Engineer and the Design needs of a modern curriculum. Of particular interest is the fact that the redesign was the result of a Design Thinking process, mirroring precisely what the students learn in the course.

Keywords: Innovative experiences in engineering education; Interdisciplinarity; Implementation of pedagogic changes; Student engagement in learning.

1 Introduction

According to Dym et al. (2005), the design process in an Engineering context can be defined as follows:

> *Engineering design is a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints.*

From this definition, the same authors highlight the skills associated with good designers:

- tolerate ambiguity that shows up in viewing design as inquiry or as an iterative loop of divergent-convergent thinking;
- maintain sight of the big picture by including systems thinking and systems design;
- handle uncertainty;
- make decisions;
- think as part of a team in a social process; and
- think and communicate in the several languages of design.

The importance of developing these skills is a core component of successful innovative approaches in Engineering Education (Somerville et al., 2005) and the new Engineering program of Insper, a non-profit education and research institution in Brazil (Soares et al., 2016). For this development, it is particularly important to introduce the set of standard strategies for design processes, known popularly as Design Thinking.

However, introducing Design Thinking is particularly difficult because of historical reasons: during the first half of the 20th century, there has been a movement to establish Engineering as a science, focusing on precise foundations instead of practical applications (Tadmor, 2006). This scientific movement resulted in design not being seen as part of the commonly accepted definition of an Engineer, and therefore facing resistance from both students and faculty (Evans, 1990; Todd & Magleby, 2004). The ideal solution for this difficulty is either pushing a cultural shift or building an admission process that filters out resistant individuals, but it is not reasonable to expect a new program to achieve such an ambitious goal in the short term.

In this paper, we describe *Co-Design of Applications*, a course offered to students in the second semester of Insper Engineering, with the primary goal of introducing Design Thinking. In particular, we compare the first and second iterations of the course and describe the specific changes that addressed significant issues and increased student motivation without compromising its main purpose. One of the most important changes was the addition of Front-End Development as a secondary goal.

Section 2 details the background that contextualizes the description: the Design Track of Insper Engineering and the current importance of Computer Programming in Engineering and Design. While the latter does not seem related at first sight, it played a key role in the aforementioned addition of Front-End Development. Sections 3 and 4 detail the first and second iterations: the principles followed, the structure used, and the feedback received. Section 5 shows quantitative data that objectively confirm the improvement from one iteration to the other. Section 6 presents some conclusions and future work.

2 Background

2.1 The Design Track of Insper Engineering

The undergraduate Engineering programs of Insper are Mechanical Engineering, Mechatronics Engineering, and Computer Engineering. During the first four regular semesters, all three programs share a *Design Track*, a sequence of courses specifically included to introduce different aspects of Design.

- In the first semester, all students have the *Design Nature* course, which is focused on physical prototyping. This course does not present the entire Design Thinking process, but does present some issues that this process supports to solve.
- In the second semester, all students have the *Co-Design of Applications* course, which enables students to experience the entire Design Thinking process and also includes digital prototyping as a secondary goal.
- In the third semester, Mechanical Engineering and Mechatronics Engineering students have *Design for Manufacturing*, and Computer Engineering students have *Agile Collaborative Development*. Despite being different courses for better contextualization, these have the same main goal: develop design competences in a more complex context that requires specific techniques of project management.
- In the fourth semester, all students have the *Technological Entrepreneurship* course, which closes the cycle by allowing students to practice design in a complete context of business modelling.

It should be emphasized that the Design Track does not end in the fourth semester, but moves to more specific topics that are outside the scope of this paper.

2.2 Computer Programming in Engineering and Design

Computer Programming is a skill naturally associated with Computer Engineering, but in an industry survey by the American Society of Mechanical Engineers (ASME, 2012), *computer programming/software* was the second most voted option for *most needed skills in the future*, with 19% of the votes. In other words, Computer Programming is being recognized as an important skill for Engineers, regardless of which specific major they intend to work with.

Considering this context, it is natural to ask which programming language would be more adequate to introduce this skill. The TIOBE Index (2017) shows that lower level languages like C and C++, traditionally associated with Engineering courses, are on a popularity decline, while higher level languages like Python and JavaScript are on a popularity rise. This is confirmed by statistics from the well-established repository service GitHub (2017) and a recent survey by Stack Overflow (2016). The latter is particularly interesting because JavaScript is relatively high even in the *Math & Data* category, above traditional data processing languages like R and MATLAB.

We emphasize JavaScript because it is strongly used in Front-End Development, being used for website layout and behaviour, and therefore represents a natural bridge between Engineers and Designers. There has been a recent movement to encourage Designers to learn programming (Stinson, 2017) even if not necessarily for production (Treder et al., 2017). The reasoning is that a basic knowledge of programming allows Designers to empathize better with Engineers by knowing their constraints (Cooper, 2017).

3 The First Iteration: Second Semester of 2015

3.1 Principles

In the first iteration, the principles were based on research about existing courses.

- We decided to restrict the solutions to mobile applications to ensure that the solutions were simple enough to be prototyped multiple times.
- Knowing in advance that the solutions would be restricted to mobile applications, we could include digital design and digital prototyping as part of the course.
- We assumed that Project-Based Learning was an effective method to teach Design Thinking (Dym et al., 2005) and Design Thinking is a necessary tool to use Project-Based Learning (Parmar, 2014).
- We established that a correct process would be more important than an impressive deliverable.

3.2 Structure

The semester was divided in two parts, each associated to a project.

- The first project was designing an application to solve a problem faced by students themselves.
- The second project was designing an application to solve a problem related to a hospital. We used a partnership between Insper and the Albert Einstein Israeli Hospital to facilitate access.
- Each week, students had one 4-hour meeting with the professors. This meeting was used for small lectures and guided studios to develop the project.
- Only a low-fidelity prototype, built for example with paper or tools like Balsamiq (2017), was required at the end, but those who wanted to develop a high-fidelity prototype were encouraged to do so.

The content of the lectures was based on the Design Thinking material from IDEO.org (2017) and d.school (2017) and guest specialists were invited to talk about Graphic Design and Usability. Optional workshops about Intel XDK (2017), a fast and easy tool for developing applications for multiple platforms, were also offered for students interested in actual development.

3.3 Feedback

The first iteration was not very well-received by students, who pointed out significant issues:

- Having two projects implemented with the same process felt redundant.
- In the first project, it was very difficult for the students to not see themselves as users.
- In the second project, working only with hospitals felt excessively constrained.
- The course structure was too loose and lacked feedback.
- 4-hour meetings were too tiresome.
- Some students felt frustrated by having to implement an application instead of a general solution.
- Demanding only a low-fidelity prototype did not feel motivating, because at the end they did not have something to show and feel proud about.

- The Intel XDK platform had many bugs, and was difficult to use.

On the other hand, the students liked the content brought by the guest specialists and were interested in knowing more about Graphic Design and Usability.

4 The Second Iteration: Second Semester of 2016

4.1 Principles

In the second iteration, the principles were based on the feedback of the first iteration.

- We needed to ensure that projects were different enough to keep the students motivated.
- The students were interested in learning about Graphic Design and Usability.
- The students wanted less constraints with respect to the group of users they were developing for.
- The students were interested in learning tools for high-fidelity prototyping.

4.2 Structure

The semester kept divided in two parts, each associated to a project, but their nature changed significantly.

- The first project was building a portfolio website with less focus on the design process and more focus on Graphic Design, Usability, and Front-End Programming.
- The second project was designing an application for a chosen group of users that could be found in campus neighbourhood. Students had complete autonomy to choose a group, as long as no member was part of it. Some examples were tattoo artists, hair stylists, and security guards.
- The meetings were still used for small lectures and guided studios to develop the project, but they became two 2-hour meetings per week.
- A high-fidelity prototype was required. Students could choose between learning a prototyping tool or using the Front-End Development skills learned during the first project, to build this prototype.

Graphic Design and Usability topics were brought as part of the regular lectures, without the need for specialists, and were taken from the books of Williams (2014), Cooper (2004), and Norman (2013). The Flipped Classroom method (Bishop & Verleger, 2013) was used to teach programming: students would learn the HTML, CSS, and JavaScript programming languages from Codecademy (2017) and apply their knowledge in specific deliverables during the meetings. For those interested in alternative tools for prototyping, references about Bootstrap (2017), jQuery (2017), Axure (2017), InVision (2017), Cordova (2017), and Ionic (2017) were given.

4.3 Feedback

While the second iteration still had issues pointed by the students, most issues that were pointed in the first iteration seemed to be addressed. However, two new issues rose:

- Some students felt that there was an excess of content, and as a result part of it was presented too superficially. They liked the content, but wanted to see more details of it.
- There was some disagreement among students on whether they should see *Co-Design* as a design course or a programming course.

The overall impression was that issues were more related to communication than the structure itself.

5 Comparative Results

At the end of each iteration, a questionnaire with three questions about demotivation and three questions about motivation was given to the students. Each iteration had three student sections, but in order to ensure a fair comparison, we only considered the sections associated to a professor that participated in both iterations. This professor was associated to one section in 2015 (19 students) and two sections in 2016, which we will call 2016A (15 students) and 2016B (17 students). In all figures below, the left graph refers to 2015, the middle graph refers to 2016A and the right graph refers to 2016B. Each graph is a histogram representing the percentages of answers across a 0 to 10 scale, with 0 being *completely disagree* and 10 being *completely agree*.

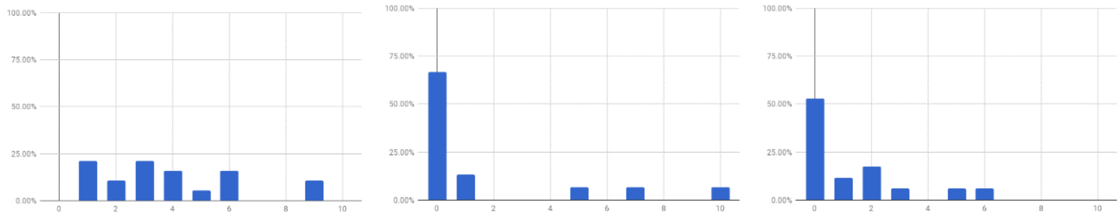

Figure 1. Histograms for "regardless of how much effort I put into it, I don't learn the contents of this course".

Left graph is 2015 (mean 3.84), middle graph is 2016A (mean 1.60), and right graph is 2016B (mean 1.29).

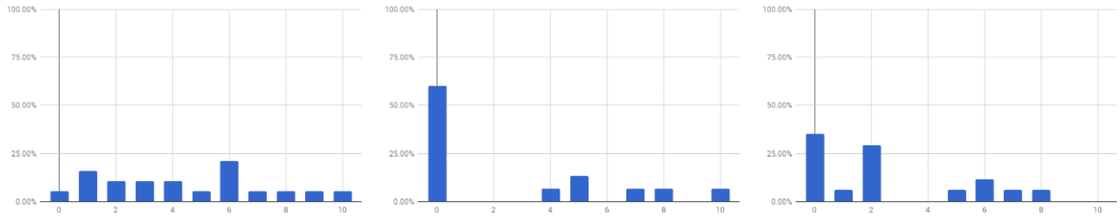

Figure 2. Histograms for "I'm not sure if learning this is important".

Left graph is 2015 (mean 4.42), middle graph is 2016A (mean 2.60), and right graph is 2016B (mean 2.53).

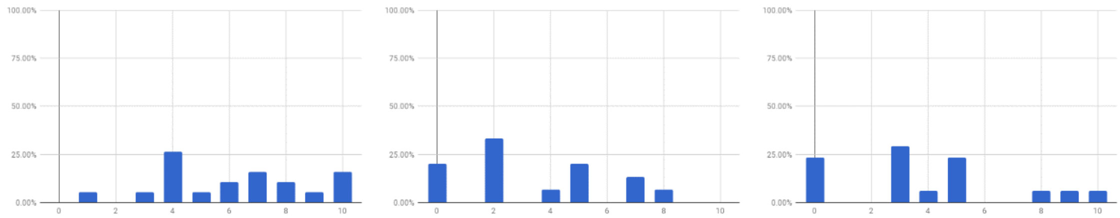

Figure 3. Histograms for "I think I'm learning just a few notions about the contents of this course".

Left graph is 2015 (mean 6.16), middle graph is 2016A (mean 3.40), and right graph is 2016B (mean 3.88).

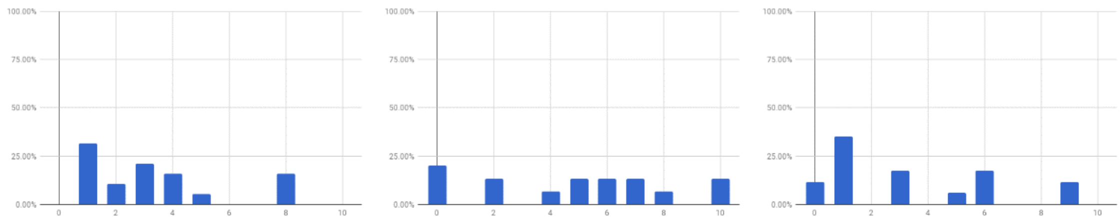

Figure 4. Histograms for "I keep waiting for when I'll have a new class of this course".

Left graph is 2015 (mean 3.32), middle graph is 2016A (mean 4.80), and right graph is 2016B (mean 3.29).

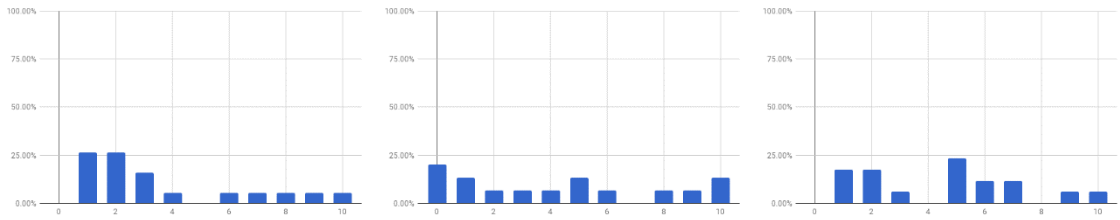

Figure 5. Histograms for "I can do what I really like in this course".

Left graph is 2015 (mean 3.58), middle graph is 2016A (mean 4.27), and right graph is 2016B (mean 4.87).

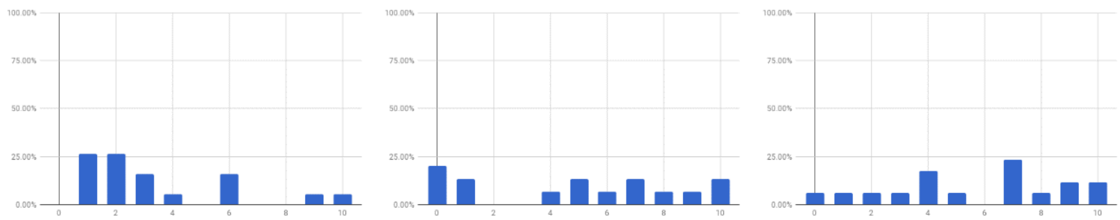

Figure 6. Histograms for "this course is fantastic".

Left graph is 2015 (mean 3.42), middle graph is 2016A (mean 4.53), and right graph is 2016B (mean 5.71).

With a single exception (2016B in Figure 4), the 2016 sections consistently had lower responses for the demotivation questions and higher responses for the motivation questions,

6 Conclusion

We described the background, the first iteration, the second iteration, and comparative results of the *Co-Design of Applications* course of the Engineering program of Insper. The results show that we successfully managed to listen to student feedback and improve the course between iterations, without losing sight of its original goals. It should be emphasized that the feedback and redesign process was essentially a Design Thinking process, making the course its own example of "practice what you preach".

There are plans for addressing the remaining issues in future iterations, by increasing the amount of Flipped Classroom to allow a deeper presentation of technical content and use books better tailored to introduce Graphic Design to Engineers (Kadavy, 2011) and communicate design to non-designers (Greever, 2015).

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Customizing rubrics to enable open-themed projects in Robotics and AI

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Abstract

Differently from traditional Robotics and AI classes, that tend to focus deeply on one AI technique or kind of task at a time, Insper's Robotics class focuses on enabling students to be integrators of AI techniques on a real robotics platform. Such class, for second-year Computer Engineering students, is entirely based on projects. This class provides, through basic projects, a scaffolding that familiarizes the students with major approaches to problem solving within AI. After this first stage, students can then choose an open themed course term project to be developed in groups. The rubric used for the assessment of the final project was customized for each theme and group of students. One remarkable result was the confidence reported by students in the assessment process and in their own project, feeling that the outcome was in their own hands.

Keywords: Rubric Design, Education in Robotics, Education in Artificial Intelligence, Problem-based learning

1 Introduction

Traditional Robotics and Artificial Intelligence courses usually focus on basic techniques and algorithms such as control systems, logic-based planners, localization on maps, computer vision, search-based action selection and state machines, that can be used to build larger, more complex systems. These are then studied and applied in isolation in order to study their strengths and limitations in depth. However, students rarely integrate these techniques to build a full AI solution or an actual robot.

With the maturity of modern toolboxes and software infrastructure such as the ROS - Robot Operating System (Quigley et al, 2009) and Scikit-learn (Pedregosa et al, 2010), there is a need for an AI integrator that can design a robotic system in high-level and employ robust publicly available implementations into a solution for a robotic mission. This professional is not an expert in every AI subfield contributing to the solution, but s/he has a strong grasp of what each technique can do and understands how to effectively combine them.

We designed a Robotics and AI course for second-year students in Computer Engineering that focuses on this practical approach. The class presents major AI problems using bi-monthly projects that emphasize their understanding by applying them in controlled but realistic scenarios. The course also contains a term project where students propose a subject and implement it throughout 5 weeks.

A central challenge in the term project was measuring students' progress in a fair, informative and objective manner. Existing rubric design approaches for open-ended projects (Zytner et al, 2015; Bishop et al, 2012; Tio et al, 2014) emphasize abstract learning objectives in broad areas, such as "Problem analysis" or "Project complexity", and use potentially vague adjectives to measure the degree of mastery of the learning objectives. Although these rubrics may help instructors to evaluate the projects, from the point of view of the student they might not be neither fair, nor informative or objective. Since students are not experts, they might have a hard time understanding how the rubric applies to their own projects or misjudge their own work when applying the rubric.

In Jonsson and Svingby (2007), it was proposed that rubrics could be used as a teaching tool as well as a means of assessment. The authors argue that rubrics make the criteria and instructor's expectations clear and help students to assess their own work. Other works (Bolton, 2006; Reddy and Andrade, 2010) share similar experiences on the potential of rubrics to help students to identify weaknesses in their works. The authors of (Reddy and Andrade, 2010) note that students must be taught to use the rubrics for this purpose and that, unfortunately, research in this area is still lacking and not much can be concluded yet.

Instead of using the same rubric for all projects, we designed customized learning objectives for each project and described several levels of proficiency. Each level described concretely what needs to be done to achieve it, ranging from a basic prototype to a complete work with good usability and few limitations. We pooled students to check if using custom rubrics for each project resulted in a fair evaluation and helped them to identify points of improvement in their projects and to estimate the amount of effort required to obtain a particular grade. Results were encouraging, with most students feeling that custom rubrics did not create an unfair evaluation and reporting that they were able to guess their final grade based only on the rubric. Many students also reported that the rubric helped them to plan their efforts.

2 An overview of the Robotics and Artificial Intelligence course

Both Artificial Intelligence and Robotics are broad fields that cover a very diverse set of topics. For instance, the classic "Artificial Intelligence: A Modern Approach" (Russell and Norvig, 2003) book covers topics from classical logic to path finding and machine learning. This issue of large breadth is present in Robotics as well. One can focus on low-level topics such as control and mechatronics (Bolton, 2008; Manke, 2010) or on high-level topics such as machine vision (Szeliski, 2010) and planning to solve complex tasks (Russel and Norvig, 2003). Thus, it is very hard to design an undergraduate course that delves deep in many topics while still providing students a practical experience on how to actually build and code a robot.

With the help of Olin College of Engineering, we developed a Robotics course for third semester students in Computer Engineering based on bi-monthly projects that emphasize practical aspects of robot building. At this point of the course students have already had two courses focused on programming using Python and are familiar with using external modules installed via pip (or conda) and can design basic algorithms.

This robotics course emphasizes computational aspects of robot building instead of the lower-level, more physical aspects such as mechanics, actuators and electronics. Although those subjects are very important, they are covered in more depth in other classes. Each group of students works on a Neato vacuum cleaner robot coupled with an onboard Raspberry Pi 3 that is responsible for video streaming and higher-level control of the robotic base, this is the same setup used at Olin College in the Computational Robotics course. The Neato itself has an ARM processor that is responsible for low-level control of the motors. All software is built on top of the Robot Operating System (ROS) (Quigley et al, 2009).

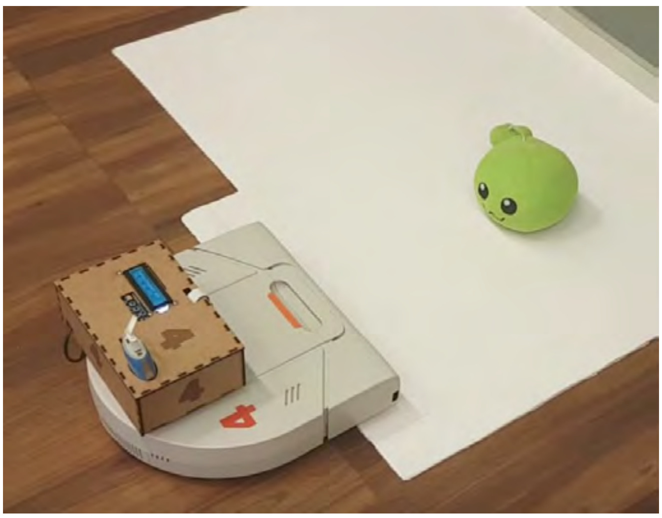

Figure 1: Neato robots were controlled by Raspberry Pi using the Robot Operating System.

The first course project focused on programming the robot to make it react to visual stimulus, and could be developed by groups of up to 3 students. The project could be coded using OpenCV or the Alvar marker detection library for the computer vision part. Behavior was coded in an event-driven pattern as a reaction to the visual stimulus and input from the robot's bumpers and LIDAR. To support the development of the project, several “mini-lectures” of roughly 30 minutes were presented during the first three weeks. After this period most classes were completely practice-focused, with the students managing their own progress and having regular checkpoints with the teaching team. The rubric for the project rewarded increasingly complex robot behavior and adaptability of the visual system.

The second project focused on localization using particle filtering. As in the first project, a small number of “mini-lectures” presented the basic theoretical concepts at the beginning of the project. Students used most of the in-class time to implement particle filtering based on a scaffold that simulated LIDAR readings. The most advanced grade was assigned to students that implemented the filter successfully and demonstrated it using the Simple 2D Robotics Simulator that is part of ROS.

The final project was open-ended to allow students to delve deeper in subjects they were more interested. Teams of up to 5 students were allowed, most students proposed topics that were not covered before in the course and ranged from more theoretical to practical experimentations. For instance, even though two groups worked on path finding algorithms like A* and Dijkstra, one decided to implement both algorithms from scratch and compare the way each one explores the space before finding the solution, while the other group worked with an already public implementation and focused on the use of path finding to define the behavior of an agent.

3 Custom rubrics for open-ended projects

There are many ways of designing rubrics, SMART (Conzemius and O'Neill, 2009) and ABCD (Mager, 1962) being two popular alternatives. SMART is an acronym guide the creation of rubrics that are **S**pecific to a single task, **M**easurable, **A**ttainable, **R**elevant and **T**ime-bounded. ABCD takes the same approach, guiding instructors to create rubrics for a certain **A**udience describing a **B**ehavior executed under clearly defined **C**onditions and performed at least to a certain **D**egree of mastery. Although these tools are valuable when writing learning objectives for activities that are reasonably closed, we have found it hard to apply them to assess the performance of students in the final project. Since groups proposed projects of varying complexity and very different topics, it is not reasonable to expect that a single rubric could be Relevant for all projects or could describe a set of Conditions common to all themes. Also, we would like the rubric to be informative to students and to help them to identify their project's weaknesses and how well they fare in each criterion. These two requirements would be associated to a learning objective being Measurable in SMART and would describe the Degree of mastery in ABCD. However, how can we measure effectively progress and mastery in projects with very distinct complexities and topics? Thus, designing a rubric for open-ended projects that aids the instructor's evaluation and is informative to students is indeed a challenge.

Apart from scale and length, our term project shares many similarities with capstone projects: each student or group of students is expected to produce (i) a proposal of the topic they desire to explore; (ii) a software that showcases their outcomes; and (iii) a report, including external references and attributions, with a detailed explanation of their topic and how they implemented the software. Due to time constraints and student maturity, the results of the term projects are not expected to be at the same level of a capstone project. However, literature on designing rubric for capstone projects should also apply to our open-ended projects.

Rubric design for capstone projects in Engineering (Zytner et al, 2015; Bishop et al, 2012; Tio et al, 2014) seems to focus on the assessment of broad skills like *Problem analysis*, *Design* and *Communication*. Elements of evaluation are described in a generic way e.g. “Identification of Problems and Formulation”, “Project management”, “Economic considerations”. The expected proficiency of learning outcomes is typically presented with positive qualifiers such as “clear”, “detailed”, “professional quality”, “engaging” or negative ones such as “unclear”, “poor”, “vague”, “fair”. In both cases the rubrics are the same for all students and, in the case of (Bishop et al, 2012), are shared amongst multiple engineering courses.

One important aspect of the rubrics presented in (Zytner et al, 2015; Bishop et al, 2012; Tio et al, 2014) is that they do not mention specifically the content of the projects. Although they do try to measure the advancement and complexity of the student projects, the rubric does not specify, for each project, what constitutes such advancements and how much complexity is involved. From the perspective of the student, who is not a specialist on the project's topic, it is hard to understand in concrete terms what s/he needs to achieve or how much s/he needs to improve order to earn a specific grade. In fact, both articles report that students seek for clues about the expectations of instructors in the rubrics. In (Bishop et al, 2012), it is reported that "*Many students seem to prefer very specific rubrics as such rubrics can provide great insight into the requirements of deliverables and the expectations of instructors.”*. In (Zytner et al, 2015), it is reported that "*One challenging aspect is that it has been observed that some students are “writing” to the rubrics. These students feel that the indicator statements need to be specifically addressed in the report under separate sections that have the indicator statements as the head.*". In (Tio et al, 2014), students filled a survey about the rubrics and reported that “*We can use [the rubric] as a guide to understand what the assessors are looking for”* (regarding how rubrics have helped them in the project) and "*Comments on where and how we can do better.*" (regarding what the proposed rubric lacked).

Another problem reported in (Bishop et al, 2012) is the difference in deliverables between projects and courses. It is reported that "For example, *the communication rubric was applied to the final project report in the course. The course instructor presented the rubric in its entirety so some students were confused by the existence of an assessment of oral performance for a written report.*". Although the authors' solution to these problems were based on better communication with students and better descriptions of the deliverables, a rubric is supposed to enhance clarity in the evaluations, not to require more explanations about it. In (Tio et al, 2014), the authors solve this communication issue by using the rubrics in a midterm progress evaluation. Students are, then, able to improve on the feedback received and are also more aware of the criteria they are being evaluated by.

We experimented with a different approach in our Robotics and AI course. Instead of designing a "master" rubric that tries to encompass very different types of projects we developed a custom rubric for each project. Sections related to communication (writing, presentation and/or reporting) were common to all projects, but each had specific learning objectives that described concretely what must be accomplished to achieve a particular proficiency in that objective. Thus, instead of criteria such as "Complexity of the project" measured using vague qualifiers such as "fair", "adequate" or "lacking", the learning objectives listed exactly what students needed to do in the context of their particular project. See the rubrics used in some of the projects in Table 1. The criteria for a basic, proficient or advanced project are labelled clearly and students have a clear path forward in order to improve their grades.

One of the factors that was taken into account for the customization of the rubric was that the projects should be challenging enough to motivate students, but attainable in order to not discourage them, and the more basic levels should serve as a proper roadmap to what an advanced project should look like.

Another factor that was used in designing the rubric was the level of maturity and functionality that was provided by libraries, tools and examples that could be used. For instance, given a good enough training dataset, it is known that OpenCV combined with Scikit-Learn can achieve performance in discriminating people's faces and identifying one person among a few that is acceptable enough for a proof-of-concept. As with many classifiers, there are problems with generalization. The projects "Reactions in social networks using facial recognition" and "Facial identification" would both build on top of OpenCV and Scikit-Learn but try to train classifiers (or a combination of classifiers) that were able to generalize in different ways.

An important consideration for the customization of the rubric was the track record of the members of the team in learning by themselves in the two first projects. Some individuals have shown competence in seeking and evaluating new information adequately before applying it to their first projects. In such cases, the rubric for the more advanced levels intentionally included challenges that would exercise their ability of learning to learn. Other individuals though have demonstrated in the first projects that open-endedness made them lose their focus and miss deliverables. For those individuals we tried to be more specific. One could argue that ideally all students should be able to pursue and evaluate new skills and apply them to their projects, but we preferred to suit the rubric to what in our opinion would give the students the greater chance of success.

The instructors had needed to rely on their previous experience on some of the subfields of AI in order to gauge properly the technical difficulty of a project and also how mature the available tools and techniques were. In some of the cases where the instructors didn't have previous experience, a survey of the tools was made and a rubric was designed in a more cautious way, erring on the side of making the project more achievable.

We also use the rubric as a teaching aid to help students understand concretely what "basic", "proficient" and "advanced" means in the context of each project. Since all rubrics were public, they could also gauge the difficulty of their colleagues' projects. Other studies (Andrade, Valtcheva, 2009) also propose the use of rubrics as a teaching tool and as a way of self-assessment by students. By examining the rubric carefully students can identify weaknesses and strengths of their projects and decide how to best apply their efforts to improve. In fact, (Tio et al 2014) reports that most students agree with the affirmation "*I feel that this set of rubrics is also applicable whenever I do a presentation on a project in the future*", which is a strong indication of the teaching potential of rubrics.

Project	C - Basic	B - Proficient	A - Advanced
Reactions in social networks using facial recognition	Basic facial recognition from the camera triggers a reaction in the social network.	At least two different expressions are recognized and translated to different reactions in a social network.	Same as B, but using 5 expressions or gestures.
Action planning in games	For at least one agent, show an example where the agent achieves the objective using one action.	For at least one agent, show an example where the agent achieves the objective using an action leading to an intermediate state.	For at least one agent, show an example where the agent achieves the objective using at least two actions leading to an intermediate states.
Facial identification	Scripts for capturing and training the facial identification system. A prototype that identifies accurately at least 3 people.	Given a trained classifier with 5 people, identify who appeared in a video containing only frontal shots.	Same as B, but with 2 faces standing far away from the camera.

Table 1: Examples of the proposed custom rubrics for different projects. We only present the passing grades, but two failing grades were also included in the evaluation. The full set of rubrics is at http://goo.gl/g7rGAN

4 Results

All 24 students enrolled in the course obtained passable grades (distribution of grades shown in Figure 1). A significative number of students achieved the highest grades (A, A+) and have shown a strong commitment to the project. Many of the students with the lowest passing marks purposely did only the necessary to pass.

C	C+	B	B+	A	A+
6	3	6	0	5	4

Table 2: Distribution of students' grades.

To evaluate the perceptions of the students regarding their customized rubrics we applied a survey containing 10 questions that aimed to validate the following hypotheses:

1. The use of custom rubrics does not create unfairness;
2. The use of custom rubrics helps student to assess their own progress;
3. Custom rubrics help managing student's expectations and efforts;

We also included an open comments field and control questions to assess whether students actually read their group's rubric and were aware of what they needed to do in order to achieve each level. We obtained answers from 17 out of 24 students. All pooled students were aware of the rubric for their group and most (almost 90%) had read it carefully.

We evaluated the hypothesis 1 (*The use of custom rubrics does not create unfairness*) using students' agreement with three questions: "I considered the ratio difficulty-grade fair", "My group was satisfied with our grade" and "I was satisfied with the results of our project". Responses are shown in Figure 2. Agreement with the three questions was massively positive, which strongly supports our hypothesis that custom rubrics did not create unfairness.

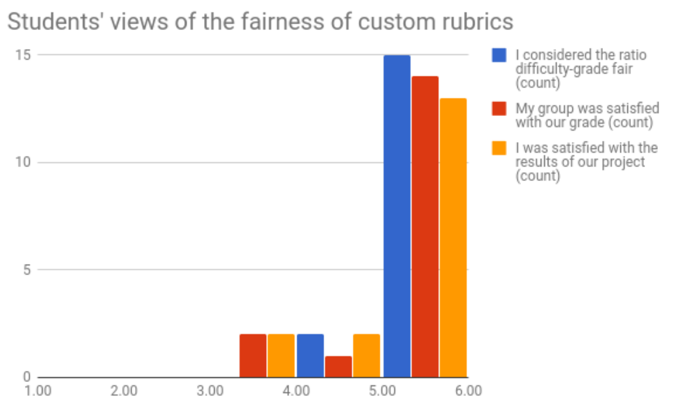

Figure 2: Students' views of the fairness of custom rubrics

We evaluated hypothesis 2 (*The use of custom rubrics helps student to assess their own progress)* using students' agreement (rated from 1 to 5) two statements: "I knew my group's grade before the final evaluation" and "My grade was consistent with my efforts". As seen in Figure 3, students were able, to a certain degree, to assess their own work successfully. More than half the students (11 from 17) were very confident on their self-evaluation and there were no students that were completely surprised by their evaluations. Also, students felt that their grades reflected their efforts, which means that students were able to correlate their efforts with the learning objectives stated in the rubrics. Finally, about half the students agreed with both statements and only two students were neutral in regard to one of the statements.

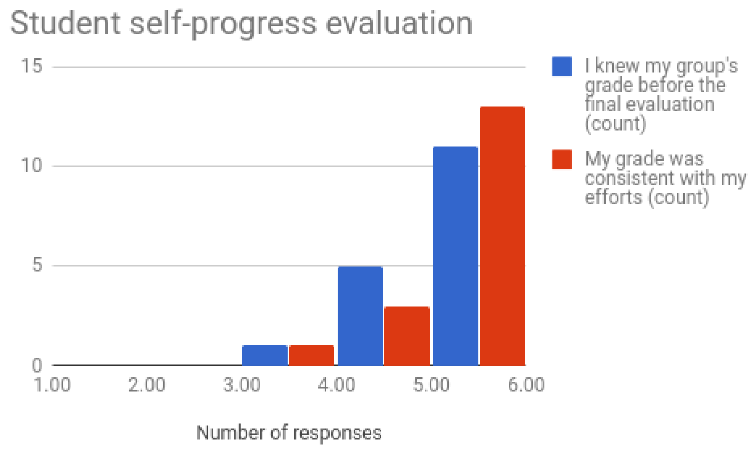

Figure 3: Student self-progress evaluation

We evaluated hypothesis 3 (*Custom rubrics help managing student's expectations and efforts*) using agreement (rated 1 to 5) with three statements: "*My group used the rubric to determine how much time to invest in the project*", "*The rubric helped me to manage my time*" and "*My group used the rubric to prioritize features*".

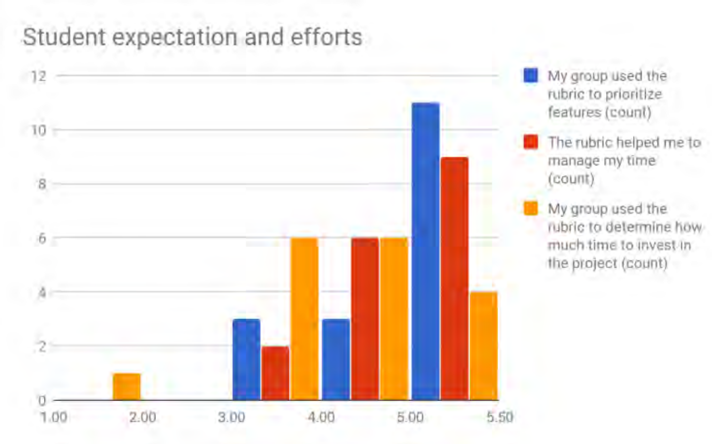

Figure 4: Student expectations and efforts

5 Final remarks

Besides the positive evaluation of the use of custom rubrics, two interesting interactions occurred during the term project. One of the groups initially proposed to work on algorithms for self-driving cars based on simulator used in a Udacity course. Unfortunately, many hiccups were found in the project setup and they were unable to achieve meaningful results. After some deliberation, the group decided to cancel this proposal and submit a second one to work on intelligent agents for game development. They reported that the rubric helped them realize that they would not be able to complete their initial proposal.

A second group also interacted with the rubric. After some work in the project they realized that one of the criteria was too restrictive based on the conditions of the project. They proposed an adjustment in the rubric that calibrated better their success. Since it was reasonable, the adjustment was accepted.

An obvious problem with our approach is how scalable it is and how to cope with the breadth of an area such as Robotics. A possible way to cope with this problem is making the criteria more explicit and having the teams design their own rubric.

6 Future work

Our results indicate that students were able not only to use the rubric as self-assessment but they "interacted" with it, proposing changes and discussing how to prioritize their work. An interesting direction would be to let students co-design part of the rubric based on an explanation of what criteria it should measure. Since the highest concept is only attributed to outstanding projects, we hope this would encourage students to aim higher in their projects by taking on challenges they have proposed themselves.

7 Acknowledgements

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Physical Layer of Computing: a contextualized view of Electrical Engineering for Computer Engineers

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Abstract

Computer Engineering is a field that evolved, in great part, from Electrical Engineering. In fact, a key distinction between Computer Engineering and other computer-related programs that are more mathematically-oriented (like Computer Science) or software-centric (e.g. Information Systems) is the consideration of the physical reality upon which computer systems are built - its possibilities and limits. In traditional Computer Engineering programs there is a knowledge gap between basic undergraduate-level Physics courses and the construction of modern computer systems, below the level of digital computer design and operating systems. With this realization in mind, we designed a course to familiarize Computer Engineering students with essential topics on Electronics, Energy, and Telecommunications. We named this course “Physical Layer of Computing”, in analogy with the “Physical Layer” of the OSI Network Model: it is the basis that supports the rest of the technological stack. As a guiding principle for the choice of topics covered in the course, we seek to construct, in our students, an understanding of how the limits of modern computing solutions are shaped. The course also develops further important horizontal competencies - namely, technical writing and self-directed learning. Students work in a report on a topic of their choice, among the fields discussed in the course. The report takes the shape of a conference paper and presentation, but focuses on field surveying and historical context. The submitted reports go through a round of “peer review” before “final submission”. The reports are presented in a final event that resembles a conference, and the combined set of reports is made into a “proceedings” book. Students reported a high level of motivation in this activity, which translated into greater participation in lectures - particularly those related to their individual topic of writing.

Keywords: Computer Engineering Education; Horizontal Competencies; Self-directed learning; Context Awareness.

1 Introduction

Computer Engineering has been traditionally construed as a discipline that bridges the gap between Electrical Engineering and Computer Science, and is centred around the design of hardware and software for modern computer systems (ACM-IEEE 2016). It is the connection to the physical realization of computing that distinguishes Computer Engineering from a more mathematically-oriented discipline such as Computer Science. A Computer Engineer must make design decisions related to the performance and feasibility of computer systems that involve consideration of physical aspects such as:

- How much energy will it consume? How available will the energy be in the specific context of a given project?
- How fast can the computing system be? What about the future?
- How much time will it take to transfer data to a remote device? How far can we reach?

The “Physical Layer of Computing” course was designed to provide students with a basic understanding of the core elements of Electronics, Energy, and Telecommunications, as they relate to Computer Engineering. The name is a word-play on the “Physical Layer” of the Open Systems Interconnection model (ITU 1994), which specifies the physical elements of a computer network and how it relates to the upper layers of the network stack.

Besides the technical content of the course, students develop their writing and presentation skills, in an effort to foster their self-directed learning abilities. The reason for this preocupation resides in the recognition that this course is not a “core Computer Engineering” discipline, but one that is invaluable for a computer engineer to interact with other professionals (such as electrical engineers) in a multidisciplinary project.

Habitually, courses that approach the present course in terms of material and intent are the "Electrical Engineering for Non-Majors" courses. Malik et al (2008) reinforce the necessity that such courses must be made more relevant to the students by conceptually grounding and refocusing them. Zekavat et al (2005), reflecting on the adequacy of traditional courses of this nature, stated:

> *"Traditionally, the content of this EE service course is a cut-and-paste combination of some of the content of courses offered to EE students. In addition, the traditional approach covers some limited topics in EE in detail, but does not cover the broad range of technologies in the field of electrical engineering. This practice is not consistent with growing interdisciplinary technologies and it does not adequately fulfill students' future needs."*

It is clear that a fresh design must be made for an effective course that presents essential topics in Electrical Engineering to Computer Engineering students. In this paper we present our design for such course. Section 2 presents the course content and class activities. Section 3 presents the learning goals and evaluation criteria. Section 4 presents a discussion of the results.

2 Course content and learning activities

The course components are divided into three technical areas (Electronics, Energy, and Telecommunications) and one non-technical component: technical writing and self-directed learning.

2.1 Electronics

From logic gates and combinatorial logic to modern microprocessor architecture, a computer engineer is expected to be proficient in digital design. Several courses in Computer Engineering are dedicated to these topics. What lies underneath logic gates, the domain of switching electronics, is the focus of the present segment of the course. Students are introduced to digital electronics in order to understand how digital circuits work, and what limits the performance of digital circuits. The main learning points of this module are:

- Circuit analysis and simulation: Network analysis (nodal and mesh). Network theorems. Simulation tools: small-signal analysis, time-domain analysis, sampling. Analysing non-linear circuits.
- Basic operation of electronic components: diodes, bipolar-junction transistors, field-effect transistors, MOSFET. Construction aspects. Modelling: Shockley's equations, linearized models. Biasing.
- Thermal limits in digital circuits: Power consumption, heat transfer modelling, temperature analysis, heat dissipation analysis.
- Speed limits in digital circuits: charge transfer and capacitance, inductances.

Computer simulation of circuits was extensively used in order to quickly test ideas and validate new knowledge, with the proper caveat made about the limits of simulation and the need to experiment in the real world to characterize electronic components and circuits. Topics were explored through short lectures and readings, and mini-projects in each class. In the mini-projects students were asked to design circuits and determine the best strategy to specify the various circuit components, thus developing through experimentation their knowledge about how circuits operate and what are typical operating limits in common circuits. Students also gained practice in searching for technical specifications in datasheets, and in circuit testing and debugging (albeit simulated).

2.2 Energy

Energy is one of the key issues in the design of modern computer systems, from the low-power and small-scale of mobile devices, to the large-scale energy consumption of a data-centre. In fact, power consumption issues may have unexpected consequences for a computer engineer: Herb Sutter, a prominent C++ developer and advocate, states that the revived interest in the C++ language (as of 2011) could be attributed to producing executable code that resulted in lower energy consumption, benefitting the battery duration of cell phones as well as lowering the energy bill in data-centres (Sutter 2011).

As such, a Computer Engineering student will benefit from having a basic knowledge of the power grid, and the impact that the energy infrastructure can have in the operation of a data-centre. In this course, students are exposed to the following learning topics:

- Sinusoidal steady-state circuit analysis: Phasors, power flow, power factor.
- Overview of the power grid structure: generation, transmission, and distribution.
- Power consumption in data-centres: computer hardware, HVAC, infrastructure. Backup power and on-site generation.

While quantitative design exercises were used to teach certain topics (such as power flow and power factor), the majority of classes in this module focused on qualitative discussions and strategic analysis. Students had the opportunity to discuss the power grid and the role of computer engineers in the power systems industry with an executive of a major power transmission and distribution company.

At the same time this course was taking place, students were also taking a core Physics course on "Electromagnetism and Waves". A synergy was established between the courses at this point. For instance, a student that was writing about "wireless power" in the present course built a wireless cell-phone charger for the project component of his other course.

2.3 Telecommunications

Modern computer systems are made possible by the advent of widespread, low-cost, reliable telecommunication systems. The performance of telecommunication systems has a profound impact on the design decisions a computer engineer must make in order to have an effective, responsive solution.

Knowledge of computer networks operation and design is essential to a Computer Engineering professional, and a Computer Engineering program must provide detailed teaching in this topic. However, most Computer Networks courses presented to computer engineers focus on higher abstractions of the network, beyond the physical and data layers, where communication errors are abstracted as "lost packages" and "broken connections", and communication performance is summarized as "latency" and "throughput". A more fundamental understanding of how signal communication occurs is useful to a computer engineer, as it provides a backdrop for the concepts in computer networks, and makes tangible the phenomena that is being abstracted in higher-level network models.

In this course the students are presented to the following topics:

- Signal transmission
    - Signal modelling: Fourier transforms, telecommunications band allocation
    - Modulation: AM/FM modulation, digital signaling, digital modulation (QPSK, FSK)
    - Physical media and transmission: radio transmissions by air and cable, fiber optics, satellite relay
- Communications theory
    - Entropy and compression
    - Error-detecting and error-correcting codes: parity, checksum, hash functions, Hamming codes.
    - Switching: packet and circuit-switching

It is evident that a profound understanding of all these topics is not achievable in a fraction of a course. Instead, a choice was made to focus on understanding the concepts through the application of computer simulation and physical experiments, including:

- Software-defined radio (SDR) experiments:
    - Students had the opportunity to use SDR devices to explore the radio spectrum and observe the occurrence of radio transmissions such as FM radio and TV signals. Figure 1 shows the SDR receiver (NooElec), and a half-duplex SDR radio (HackRF).
    - Students had to "hack" a small radio-controlled car: using the SDR the students had to discover the modulation and signaling scheme of a remote radio-controller to a small toy car, and acquire command of the car with their laptops.
- Radio wave transmission and media:

- Students observed the phenomena of radio signal propagation in a coaxial cable. Through changes in the termination of the cable (open-ended, short-circuited, or impedance-matched), students were able to observe the sent and reflected signal in an oscilloscope. Measuring the time for the reflection to arrive, and the length of the cable, students computed the speed of light in that media, and compared with the expected values for the particular dielectric being used.

- Signal modeling:
    - Using GNURadio, a real-time computer simulation tool (GNURadio 2017), students could observe, in practice, the effect of sampling rate, bandwidth, and aliasing, leading to an understanding of the Nyquist sampling theorem.
    - Students could experiment with AM and FM modulation in GNURadio to understand how multiple signals can be transmitted simultaneously in the same medium. Figure 2 illustrates a pipeline used by the students to investigate AM demodulation: it was used in the "car hacking" activity.

Figure 1. SDR devices: a receiver (NooElec) and a half-duplex radio.

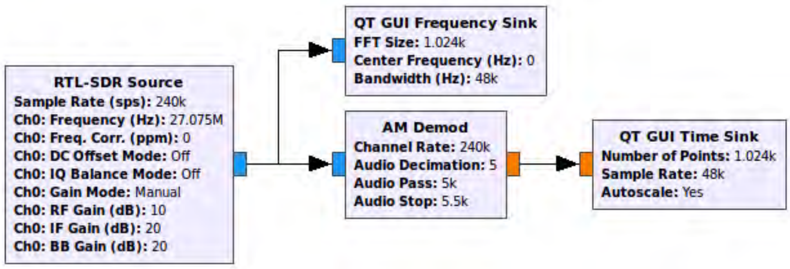

Figure 2. An example of a signal processing pipeline in GNURadio used to study AM demodulation.

Some topics, which were deemed closer to the activities of the computer engineer, were presented in a more quantitative manner, such as those related to communications theory. Others consisted in a more "free-form" exploration, such as playing with sampling rates and deriving empirically the Nyquist sampling theorem, or discovering properties of AM/FM modulation through exploration of the radio-frequency spectrum.

2.4 Technical writing and self-directed learning

It is clear that the nature of the subjects of this course are not what constitutes "core Computer Engineering" subjects, despite their importance (as seen above). Besides teaching content to our students, it is necessary to teach them how to learn about the material in an independent manner. Students must acquire the ability of self-directed learning for all subjects, evidently; but this imperative applies in particular to any subject that resides in the frontier of the "core knowledge" of the professional. Knowing how to navigate at the edge of one's knowledge allows easier communication with professionals with complementary skills, increasing the chances of success of a multidisciplinary project.

Another important ability for the future professionals in Computer Engineering is technical writing. In fact, communication is ranked among the top abilities required by industry, and one of the greatest sources of complaints by companies when hiring new graduates (Fine & Perkins 2016).

In order to promote self-directed learning and technical writing, the students were asked to choose a subject of their liking, related to the topics of the course, and write a 4-page review article on the subject. The activity was organized as if the instructor was their graduate studies advisor, and the task at hand was to write a paper and make a presentation for a conference – except that the paper focused on field surveying and historical context, rather than presenting new scientific results.

Prior to starting the writing, each student went through a short individual session of consulting with their "advisor" (the professor) to better define the topic of writing. Throughout the semester the students were presented to reading and writing techniques, such as:

- Skim reading, and how to quickly select material for a detailed reading among a large corpus of scientific papers.
- How to organize the text, from assembling an initial skeleton to finalizing the report.
- Using proper tone in writing

The submitted reports go through a round of "peer review" before "final submission". The reports are presented in a final event that resembles a conference, and the combined set of reports is made into a "proceedings" book.

Students were informed that, during presentations, two members of the audience would be chosen at random and required to ask a question to the presenter at the question period. This generated an interesting phenomenon: since no one knew who would be asked to formulate a question, all students had their questions ready at the question period. As a consequence, question periods tended to be lively, as there was a wealth of questions to be asked!

3 Learning goals and progress evaluation

For each learning goal, a set of operational definitions of competence level were designed, composing a rubric for student assessment. The competence levels in each goal were then combined into the final assessment in a manner that ensured, at a minimal level, an acceptable level of competence in all subjects of the course.

Competence levels are defined as: (I) insufficient; (D) under development; (C) Essential; (B) Proficient; (A) Advanced. Levels (I) and (D) are unsatisfactory, the remaining levels indicate acceptable performance.

Technical competences were assessed by weekly in-class short exams. Writing competences were assessed by:

- the quality of the final writing, and also
- the quality of the peer review – the *reviewers* themselves were being evaluated at that point, *not* the writer.

Presentation competence was evaluated at the final "conference".

The goals for the course, and the operational definitions of competence were as follows.

Technical competences:

Related to electronics:

T1: The student will be capable of analyzing, designing, and discussing simple electronic circuits

Level	Definition
I	Does not demonstrate basic understanding, cannot select an appropriate technique for analysis and design
D	Can list and discuss, at a basic level, design and analysis techniques, but not apply them
C	Can follow a design guide and analyse simple circuits
B	Can develop an analysis and design strategy for moderately complex circuits

A	Can analyse and design complex circuits

Related to energy:

T2: The student will be capable of analyzing and discussing simple power grids

Level	Definition
I	Cannot solve circuits with phasors and does not understand power balance
D	Cannot solve circuits with phasors or (but not both) does not understand power balance
C	Can solve phasor circuits and power flow
B	Satisfies C, and can discuss issues related to the power grid
A	Satisfies B, and can analyze cost/benefit scenarios in given problem situations

Related to telecommunications:

T3a: The student will demonstrate knowledge of essential elements in telecommunications

Level	Definition
I	Cannot demonstrate knowledge, nor relate the concepts present in a given situation involving telecom.
D	While not satisfactorily proficient in the core concepts, can point which ones are applicable to a given situation.
C	Understand channel limits, fundamental concepts in analog and digital modulation, noise and error, multiplexing, basic networking.
B	Satisfies C, and can design simple telecommunication projects (at a high level).
A	Satisfies B, can discuss the context of the area and raise future questions.

T3b: The student will be able to discuss the application of coding techniques for data compression, and error detection and correction.

Level	Definition
I	Cannot apply techniques or demonstrate conceptual knowledge
D	Can partially apply the techniques
C	Can proficiently apply the techniques, but presents only basic conceptual knowledge
B	Satisfies C and demonstrates good understanding of the concepts
A	Satisfies B and can extrapolate the concepts developed to more complex situations

Writing and presentation:

Related to writing:

E1: The student can conceive, structure, and develop a technical report of a review nature.

Level	Definition
I	Did not write the document, or presented a very poor, non-sensical report
D	Report has poor quality: poor content, badly written, or presents inconsistencies
C	Consistent text, minimal content, few writing errors
B	Good report, well written and complete
A	Approaches a more professional level, comparable to a real conference submission (apart from the focus on review rather than scientific reporting).

Related to presenting:

E2: The student can give an effective and interesting oral presentation on the report

Level	Definition
I	Did not present, or non-sensical presentation
D	Poor presentation, with quality, consistency, or completude problems
C	Coherent presentation, complete and consistent
B	Well designed presentation, that maintains the audience interested
A	Could be the presentation of a moderately good grad student

Final grade assessment of the course was produced as follows:

Level	Definition
I	Assessed I in two or more objectives
D	Surpassed I, but did not achieve C in all objectives. Note that this implies that a single objective with a D results in failing the course.
C, B, A	Surpassing D, the final grade is given as the average of all grades. The spectrum of C, C+, B, B+, A, A+ maps into the integer values from 5 to 10.

4 Results and discussion

Students reported a moderately high level of satisfaction with the overall strategy of this course. A final survey was made where students had to state, in a scale from 1 to 10, how much they were in agreement with a set of questions, results are shown below:

Questions	Average result
I'm not sure that learning this is important	1.57 (less is better)
No matter how much I apply myself to this course, I cannot learn the subject	1.56 (less is better)
The material in this course will help me in a future job	6.73
I can't wait to have another class	5.36, with an almost flat distribution of answers from 0 to 10.
This course is amazing	6.6

It can be observed from the survey answers that students may not consider this discipline to be one of their favorites, but they do recognize its importance and affirm that learning is indeed occurring. This is a favorable result for a non-core discipline. Some of the textual answers from the survey are shown below:

- "The idea of the report writing was very good, as 'boring' as it is. The weekly quizzes are very good too, with the difficulty level they presented. Also, the discussion with the power company executive was very good"
- "Keep doing the continuous-evaluation quizzes, dynamic classes and micro-evaluations. More activities like the circuit design project would be cool too!"
- "Weekly quizzes could change into every two weeks"
- "Continue to give quizzes to fixate the content. Continue to propose moderately complex exercises at the end of the lecture"

The continuous feedback offered by the short-exams was considered a positive experience by the students, with many reporting that this modality of evaluation lessened stress and imposed a weekly discipline of study. This resulted in a more homogeneous class in terms of competence, facilitating the formation of teams for the in-class mini-projects, as well as the success rates of these activities.

The writing and presentation activities were popular, and students were proud of the printed "proceedings" that each received at the end of the course, with a compilation of their reports. Some of the report titles are listed below:

- The present state of renewable energy: social, economic and environmental impacts
- The change from the third to the fourth generation of mobile phones
- How cell phone antennas work
- The WiFi and 5G evolutions
- WiFi and its health impact
- Telecommunications in the Second World War
- A history of satellite communications
- Wind energy viability in Brazil
- Wireless power: technologies and applications
- A brief introduction to quantum computing

In conclusion, this course tacked the difficult question of teaching "non-core" (or, rather, a "borderline-core") subjects from Electrical Engineering to Computer Engineering students. The approach taken was to assess the main points that connected to Computer Engineering, and structure the course around them. Also, recognizing the multiplying power to "learning-to-learn", a writing and presenting activity was developed to give students an opportunity to search for their own meaning for this course, and to acquire valuable skills for their future career. Future works include: a more comprehensive assessment of the outcomes of this course, in particular those related to writing and presenting; increasing the use of the "flipped classroom" mechanism to favor the use of class time for discussions and challenges.

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Context Awareness in Computer Engineering: Designing a Course with Algorithms and Sociology

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Abstract

The effectiveness of designing, building, and maintaining an Engineering solution depends directly on its consequences. However, traditional Engineering curricula do not consider consequences that reach beyond Exact Sciences and include, for example, social, legal, ethical, economical, and environmental aspects. A modern Computer Engineering curriculum needs, as part of its mandatory courses, a basic introduction to Humanities, which we refer to as Context Awareness.

On the other hand, in Brazilian curricula, such introduction is usually given in the form of a single Philosophy or Sociology course, isolated in the first semester with no discernible connection to other courses. Furthermore, this course is often disregarded or deliberately considered less important by faculty members or academic coordinators. The overall attitude creates a culture of apathy that extrapolates to Humanities as a whole. Alas, Humanities should be seen as a discipline that helps students to critically understand the context and support the choice of final goals.

In this paper, we describe the design and implementation of the Social Networks course, offered to sixth semester students of a Computer Engineering curriculum. The learning goals of this course are: interpreting social problems from the point of view of social mechanisms, translating sociological concepts to graph theory and graph algorithms, discussing social themes with support from data analysis made with computational tools, and formulating and testing hypotheses that explain phenomena observed in a network. This set of goals represent our intention of using tools from the Social Networks field to frame Sociology into a respectful and motivating form that integrates seamlessly into the Engineering framework while significantly contributing to Context Awareness.

We describe in the paper the assessment criteria and the classroom dynamics, which usually start by introducing social problems, focus on social mechanisms that explain the problems, model the mechanisms in the context of graph theory or graph algorithms, and finally propose a simulation using the Python language and the Jupyter Notebook platform.

Keywords: Innovative experiences in engineering education; Interdisciplinarity; Development and assessment of competences; Active Learning and ICT support.

1 Introduction

During the first half of the 20th century, a movement aimed at establishing Engineering as a science, focusing on precise foundations instead of practical applications. This scientific movement resulted in Engineering graduates that have a solid knowledge of Exact Sciences, but lack other skills needed for solving problems, the original purpose of the field. There is a consensus among employers that this original purpose needs to be recovered in order to prepare graduates for the 21st century. (Tadmor, 2006).

Aligned with this consensus, the Brazilian Ministry of Education directives for graduation programs in Engineering (MEC, 2017) establish that:

> *The graduation program in Engineering has as graduate/professional profile the engineer, with a generalist, humanist, critical, and reflexive background, qualified to absorb and develop new technologies, stimulating its critical and creative performance on identifying and solving problems, considering their political, economic, social, environmental, and cultural aspects, with an ethical and humanistic vision, meeting the needs of the society.*

What is particularly interesting about the definition above is that only the concept of technology is usually associated to Exact Sciences: all the other concepts are usually associated to Humanities. While this certainly does not diminish the importance of Exact Sciences, as they are still required to design and implement solutions strongly grounded on scientific methods, it does highlight the importance of Humanities. Furthermore, this importance is supported by recent successful cases of innovative curricula (Goldberg & Somerville, 2014).

However, a quick analysis of well-regarded Engineering programs in Brazil reveals that Humanities are usually presented as isolated courses with no connection to the other ones. At most, some of them present the social and ethical issues as context that might encumber Engineering problem solving. This is usually caused by a prejudiced view from faculty members or academic coordinators that perceive Humanities as less important, or just an unintended consequence of the aforementioned scientific movement. As a result, a self-fulfilling prophecy takes place: without a clear understanding of how these courses integrate into the program and into the profession, the students feel demotivated and end up reproducing the prejudiced view.

In this paper, we describe *Social Networks*, an innovative course offered to students in the sixth semester of the Computer Engineering program of Insper, a non-profit education and research institution in Brazil. This program has a hands-on approach to Engineering, with a strong emphasis on active learning and intrinsic motivation (Soares et al., 2016). These principles guided the design and implementation of the course. The course is organized into modules. At each module, students perform the analysis of a social context, guided by sociological insights. These insights are translated into algorithms and simulations. Next, the social network analysis' results are ultimately interpreted and translated back to the original social context in order to tackle real world social problems. In other words, it is a respectful and motivating integration that uses core Computer Engineering skills to develop critical thinking.

Section 2 details the background that contextualizes the description: the state of Sociology in Brazilian Engineering curricula and the definition of Social Network Analysis, the backbone of the course. Section 3 details the two parts of a typical course module structure: translating social problems to algorithms and simulations, and analyzing and synthesizing their results. Section 4 details two concrete examples of this structure. Sections 5 and 6 present preliminary results, discussions, and future work.

2 Background

2.1 Sociology in Brazilian Engineering Curricula

In order to understand the state of Sociology in Brazilian Engineering curricula, we considered a sample based on three well-regarded course rankings: the *World University Rankings* for *Computer Science & Information Systems* and *Engineering Electrical & Electronic* (QS, 2017), the *Ranking Universitário* for *Computação* and *Engenharia Elétrica* (Folha, 2017), and the *Guia do Estudante* for *Engenharia da Computação* (Abril, 2017). The union of the sets of top five entries is the following list of institutions, in alphabetical order:

- Instituto Tecnológico de Aeronáutica (ITA);
- Pontifícia Universidade Católica do Rio de Janeiro (PUC-RJ);
- Universidade de Brasília (UnB);
- Universidade de São Paulo (USP);
- Universidade Estadual de Campinas (UNICAMP);
- Universidade Estadual Paulista (UNESP);
- Universidade Federal de Juiz de Fora (UFJF);
- Universidade Federal de Minas Gerais (UFMG);
- Universidade Federal de Pernambuco (UFPE);
- Universidade Federal do Rio de Janeiro (UFRJ);
- Universidade Federal do Rio Grande Do Sul (UFRS);
- Universidade Federal de Santa Catarina (UFSC);
- Universidade Federal de São Carlos (UFSCar)
- Universidade Presbiteriana Mackenzie (Mackenzie).

Among these institutions, only ITA, PUC-RJ, USP, UNESP, UFMG, and UFRJ include mandatory courses related to Sociology. Furthermore, we could not find evidence in their syllabi suggesting that they follow an approach that uses core Computer Engineering skills to develop critical thinking.

2.2 The Social Network Analysis Field

Social Network Analysis is a specific field inside Sociology that models and investigates social structures with *graph theory* (Diestel, 2010), the study of mathematical structures that represent pairwise relationships. Freeman (2004) summarized the paradigm of modern Social Network Analysis as four principles:

1. it is motivated by a structural intuition based on the ties linking social actors;
2. it is grounded in systematic empirical data;
3. it draws heavily on graphic imagery;
4. it relies on the use of mathematical and/or computational models.

Although relevant contributions can be traced back to the 19th century, Freeman particularly highlights the introduction of Sociometry by Jacob Moreno (1932; 1934) and the transformative research by Harrison White (1963; 1970) as key works that allowed this paradigm.

In the past decades, the field of Social Network Analysis has experienced a strong influx of Exact Sciences. Consequently, Physics, Statistics and Economics have all make important contributions to its development (e.g. Barabási, 2009; Jackson, 2008; Kolaczyk, 2009). Yet, as a paradigm mainly grounded on Sociology, it has maintained its capacity of offering mathematical solutions to typical sociological phenomena (e.g. reciprocity, transitivity, brokerage, homophily, core/periphery, social roles). Thereby, the Social Network Analysis scholars engage in translating graph modelling to central phenomena in the Social Sciences and Humanities.

This field is a natural bridge between Sociologists and Computer Engineers, because mathematical and/or computational models are the bread and butter of Computer Engineering. As such, it provides a solid, research-based framework that assigns the same weight to Social Sciences and Exact Sciences.

3 Structure

3.1 From social problems to algorithms and simulations

The course lasts for one semester and is divided in modules. A typical module structure starts with the introduction of a social problem, and encompasses the following activities/skills: (i) *identification* of social problem; (ii) *specification* of this problem into social mechanisms associated to this problem; (iii) *translation* of these mechanisms to graph theory; (iv) *implementation* into algorithms, and (v) *interpretation* of the results. This translation allows the design and implementation of algorithms to analyse the network or simulations to estimate the evolution of social actors and their ties over time.

To illustrate this structure, consider the problem of *identifying hidden groups in networks*. A classical example stems from, for example, predicting the choice of each member when a club splits in two (Zachary, 1977; Easley & Kleinberg, 2010). A relevant result in Social Network Analysis is a method by Girvan and Newman (2002) that identifies hidden groups by simulating the removal of ties that maximize a metric called *betweenness*. This method is particularly interesting for Computer Engineers because calculating betweenness can be expensive and requires an efficient algorithm (Brandes, 2001).

To implement the algorithms and build the simulations, the students use the Python programming language (2017) with the NetworkX graph library (2017) and the Plotly visualization library (2017). The activities run on the Jupyter Notebook platform (2017), that seamlessly combines theory and practice.

Figure 1. Two screenshots of the Jupyter Notebook platform.

3.2 From computer programming to analysing and synthesizing

During the design of this course, one of the most important breakthroughs was realizing that, if the modules stopped after the steps described above, the students would learn to *translate and implement (steps iii and iv above)*, but would not develop the higher level cognitive skills (identification, specification, and interpretation – steps i, ii, and v above). In order to develop critical reflection, it is necessary to *return to the problem* and analyse and synthesize the results of algorithms and simulations under its context (*interpretation*, step v).

Therefore, the main deliverables of the course are short write-ups where they have the opportunity to interpret results and draw conclusions. The evaluation of these write-ups is based on four criteria: *understanding* of the concepts involved, *argumentation* behind interpretations and conclusions, *usage of evidence* to support this argumentation and *style* of the text itself.

4 Examples

4.1 Structural Balance Theorem

In this module, students discuss which social pressures exist in triads of individuals where the relationships are either positive or negative . The discussion is coached to converge to three pressures:

- when three individuals are all enemies, each two suffers pressure to ally against the third; (*pressure to ally against common enemy*)
- when an individual is a common friend of two other individuals that are enemies, these two suffer pressure to become friends (*pressure to bond*);
- when two individuals are friends but a third individual likes one and dislikes the other, they suffer pressure to become enemies (*pressure to divide*).

They were then introduced to the Structural Balance Theorem (Harary, 1959): when a network suffers all the pressures above, it is either *cliqued*, all relationships are positive, or *polarized*, has two groups such that all intra-group relationships are positive and all inter-group relationships are negative.

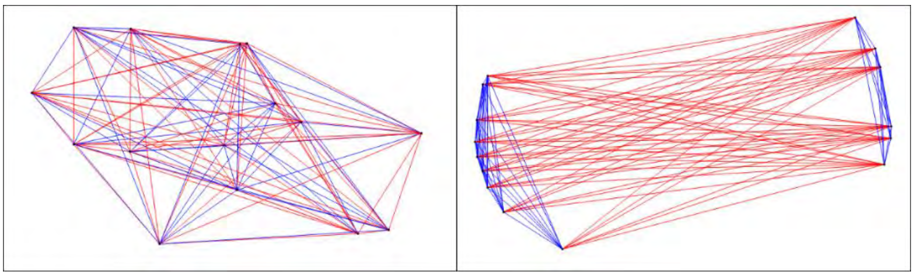

Figure 2. Visualization of two networks with positive and negative relationships. The right one is polarized.

We offered as a challenge the task of understanding what would happen to a social group where these pressures occurred in varying ways. For instance, would the graph polarize if the 'pressure to divide' was inexistent? For that purpose, they were given a scaffold to simulate the evolution of a network under varying weights of each pressure, and asked to compose a write-up interpreting the results of the simulation. The interpretation entailed inferring generic social laws.

4.2 Project Based Learning

In this module, the students read a Harvard Business Review article that analysed team making choices. Specifically, the authors investigated the extent that interpersonal perceived *competence* and *likeability* were influential on team formation. They concluded that *loveable fools* (high on likeability, but low on competence) should be preferred over *competent jerks* (low on likeability, but high on competence) (Casciaro & Lobo, 2017). They were then presented to ten different options of themes that could be related to the subject:

- jerk culture in open source communities;
- misogyny in open source communities;
- troll culture in gamer communities;
- misogyny in gamer communities;
- bullying in social media;
- coerced trust within mafia groups;
- recruitment across terrorist groups;
- portability of celebrity players across soccer teams;
- new assistant physicians selection at the *House M. D.* series;
- Donald Trump and the bad apple effect.

The students had autonomy to choose one of these themes or propose their own. They were then asked to build their own idea of simulation to model relevant social phenomena, present this idea to the colleagues, and compose a write-up interpreting the results of the simulation. This write-up was also presented to the colleagues for peer reviewing.

5 Assessment of Students goals' achievement

We measured the students' proficiency based on the course five objectives, namely:

1. Interpret social problems from the point of view of central social mechanisms.
2. Translate sociological concepts to graph theory and algorithms in graphs.
3. Based on a network that represents data on interactions and social relationships, formulate and test potential hypotheses that explain the phenomena.
4. Discuss social issues supported by data analysis performed with computational tools.
5. Relate the current situation of ethnic relations in Brazil to its history.

Objectives one to four comprise a cycle. First, students were expected to translate a social reality or social problem into specific social mechanisms (Objective 1). For instance, in one specific assignment, a group of students identified that, at gamers' communities, only few women become prominent. This social issue was translated into a few specific mechanisms. Among those, the most important that would explain the low female participation was the high homophilic behaviour among male gamers.

This mechanism was then translated into specific graph-based algorithms (Objective 2). Following the same example, students established as a starting point a random network. Further, they established the rule that males presented lower odds of connecting to female gamers. This simple starting point and set of rules generated the observed phenomena. However, in order to test different hypothesis on potential policy interventions, students were stimulated to parametrize and simulate different scenarios (Objective 3). For instance, the inclusion of a higher number of female gamers at the core of the network could make it more difficult for males to close themselves into cliquish groups. This parameter change would be akin to quota policies.

Upon generating distinct results, following the chosen analytical tools, students ought to return to the original social problems that motivated the exercise (Objective 4). This effort of translating back the analyses' results into the original context closes the cycle mentioned above. In other words, students learn how to translate from the original context into analyses and back again. Within the example explored above, students show how specific levels of quotas for females might neutralize male homophily.

While these four objectives were tested in varying degrees across all assignments, the fifth objective, related to ethnic relations in Brazil, was assessed only in the final project. Following, we illustrate how these broad objectives mapped into rubrics applied to specific assignments.

In a specific assignment, we proposed that students explored the relationship between "Small World" and innovations within the music industry. The first dimension in the rubric was "Translation of context into Social Network Analysis concepts (justification for using the techniques, given the context)", which maps to Objectives 1 and 2 above. At this dimension, we assessed whether students were able to justify why the small world model had fit with the phenomena proposed, as well as suggest hypotheses on the relationship between smallworldness and innovation. A good (grade B) explanation would spell out in an unambiguous fashion why a network's small world property was expected to be related to innovations. We considered "advanced" (grade A) those answers that included not only the small world/innovation causal connection, but would also entertain competitive hypotheses to the same phenomena.

The second dimension was "Specification and conduction of analyses", which refers to Objective 3 above. At this dimension, we assessed the technical implementation of the analyses, comprising the understanding and formalization of the social network concept code, as well as the code implementation and analyses. In an academic paper, this would be closer to 'methods', 'results' and 'attachments' sections. We granted grade B (expected) for those write-ups that included sufficient details to explain the phenomena, while the grade A (advanced) was granted to those write-ups that brought alternative analyses that triangulated the phenomena.

The third dimension was "Interpretation of the analyses (description and explanation of the analyses, returning to the context)", which is related to Objective 4 above. We granted the B grade (expected) for those write-ups that were able to offer plausible explanations, based on the evidence obtained. We had also included a fourth dimension, "Clarity of Methods and Results", related to text format and style, not directly related to any of the goals above.

6 Results

After the first half of the course, we made the following observations:

- For the most part, the students had no problem in implementing the algorithms and simulations (step iv above). In fact, some of the algorithms and simulations were excessively scaffolded and their implementation ended up being too simple and mechanical to be understood in a deeper cognitive level.
- Students also had little problem in understanding the importance of the social problems and the identification of the social mechanisms during the discussions (step i above). Further, they could easily follow how relational mechanisms (for instance, brokerage) mapped into graph solutions (e.g. betweenness centrality as the sum of geodesics a node controls) (step iii above).
- On the other hand, most of them presented significant difficulties in composing the write-ups. While style was not a problem, the criteria of understanding, argumentation, and usage of evidence was a major obstacle to some of them (step v above). When asked, they cited reasons such as lack of experience in writing and lack of time for the assignments as a whole.
- Some students felt demotivated by assignments perceived as excessively closed, and argued that they would deliver something with a greater quality if they had more autonomy over its aspects. This observation led us to propose the open project described at section 4.2 above.
- While students did enjoy engaging into more open, less structured problem solving, they resented the difficulty in specifying the social context in a constrained set of mechanisms (step ii above).

It is particularly important to emphasize that the feedbacks received so far from the students are significantly more *operational* than *conceptual*. All feedbacks stressed the importance of the course, and a perception that it belongs in Computer Engineering, which is particularly encouraging.

During the semester, we observed several hurdles that led us to introduce few adjustments. First, we felt that students had little time between assignments. Therefore, when an assignment's feedback arrived, it was too late to be incorporated into the new activity. Second, we realized that the students' effort was mainly devoted to coding and analysis reporting, and little time was devoted to interpretation. As a result, the write-ups rarely achieved the desired levels at the goals related to justification, explanation and interpretation.

This diagnostic led us to decrease the number of assignments, while increase the number of sessions devoted to each assignment. The original cycle comprised two sessions. At the first session we discussed the typical social problem associated with the social mechanism and network concept, while by the second session, students were expected to hand in the write-ups based on the suggested assignment. We promoted two changes to this original model. First, we included an intermediary session, where students were expected to bring the analyses, without any write up. Hence, at this intermediary session we would have the opportunity to help students to interpret their analysis and construct a coherent narrative before engaging in writing. Second, at the third session, we included a round of peer reviews. This allowed us teachers to become less central in the learning process, while students honed their self-assessment skills by providing feedback to each other's work.

We would like to point out some constraints that we expect to address in the future editions of this discipline. The major constraint is the extent that students perceive codes to be adaptable. We have often detected that students treated inherited codes as 'black boxes', which led to manifold consequences. Students often treated these codes as 'sacred' or 'ideal' solutions, and few attempted to change them to attain a better fit between the problems at hand and the solution. Also, students frequently did not understand why a code should be accompanied by an explanation in the write-up. For some of them, any competent code reader would be able to infer the social mechanisms by following through the code. Because codes were frequently treated as 'ideal', less than expected creative effort was expressed in the write ups, since the solutions were always constrained by the existing solution. For instance: at several situations, the context suggested that a 'random walk' based betweenness centrality should be calculated, instead of applying the off-the-shelf geodesic-based solution. Instead of performing the required adjustments in the algorithm, students settled for less appropriate approaches.

7 Conclusion

We described the background, the structure, and preliminary results of the *Social Networks* course of the Computer Engineering program of Insper. This is just the first step towards the development of a course that effectively achieves the goal of introducing Humanities and Social Sciences to Engineers in a contextualized and engaging manner, but the results so far have been encouraging and we believe that the students are developing analytical abilities that will be useful for Engineering as a whole.

We already tested modifications during the second half of the course and these were already received with positive feedback. Next logical steps are the design of activities that consciously increase intrinsic motivation (Ryan & Deci, 2000) and the gathering of quantitative data to evaluate the course as a whole.

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Developing the Next Generation of Co-operative Engineering Education

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Abstract

A new project-based model of engineering education is being developed to deliver an upper-division engineering education that is centered on student experiences working directly in industry through co-op employment. Students will work in industry, completing projects, for the last two years of their education while being supported in their technical and professional development by professors, facilitators, and their own peers through the use of digital communication. This new model will focus on learning experiences being more imbedded in professional practice, in contrast to the more traditional model of engineering where the learning about the profession is done in the abstract in a classroom. The learning experience, as designed, opens doors for greater access to engineering education. Aimed at community college graduates, it will serve a more ethnically and gender diverse student body.

This paper will explore several curricular elements of this approach to PBL engineering education through a design-based research perspective. It will focus both on the development of the program and the research approach from evaluation of the education model. The work is currently in progress; steps completed to date will be reviewed along with the plan for future steps.

Keywords: Cooperative engineering education, Professional development, University-industry partnership, Experience-centered engineering education, Design-based research.

1 Introduction

For the past few decades several calls have come for improving engineering education to meet the societal needs of today and the future (National Academy of Engineering, 2004; American Society for Engineering Education, 2015; Martin, Maytham, Case, & Fraser, 2005; Almi, Rahman, & Purusothaman, 2011; Hasse, Chen, Sheppard, Kolmos, and Mejlgaard, 2013). Specific emphasis has been on the development of the whole engineer, in addition to the traditional focus on technical, increased emphasis is being placed on the design and professional attributes of engineering graduates (Sheppard, Macatangay, Colby, & Sullivan, 2009). Crafting a student learning experience centered on engineering practice, through university-business cooperatives, has the potential to develop more practice ready engineering graduate (Lindsay & Morgan, 2016).

Just as human-centered design is changing engineering practice to involve solutions that involve the human perspective at all steps, this experience-centered engineering education experience will involve the student gaining engineering practice perspective at all steps. The current, traditional, model of engineering education could be labelled as an “indirect” learning experience where the learning about the profession is done in the abstract in a classroom. In contrast, this new model will deliver a “direct” learning experience where the profession is experienced in-situ. The learning experience, as designed, opens doors for greater access to engineering education. Aimed at community college graduates, it will serve a more ethnically and gender diverse student body (American Association of Community Colleges, 2017). Further, the financial model (students earn while on co-op) increases access to higher education without crippling student loan debt.

Entering students will have completed their lower division studies at community colleges and universities from across the US. They will enter a 6-month long Intensive Training Experience (ITE) where they will, through project-based learning, polish the skills necessary to succeed at high levels both professionally and technically as self-directed learners as they acquire and enter their first co-op. Minimum competency achievement will be necessary to move from ITE to co-op placement.

This program development is based on the successful and recently developed Iron Range Engineering Model. This model utilizes unique strategies to integrate the development of the new engineer as a professional, technical, and creative person (Guerra, Ulseth, & Kolmos, (2017). In October 2017, the Iron Range Engineering model was awarded the ABET Innovation award. The ABET Innovation Award recognizes vision and commitment that challenge the status quo in technical education. It honors individuals, organizations, or teams that are breaking new ground by developing and implementing innovation into their ABET-accredited programs. It is from this ground-breaking, award-winning model, that the new co-op model will be developed, being done so by the same development team.

The demand for engineering professionals is characterised by requirements of deep and solid interdisciplinary technical competences and communication and management skills. Changing Engineering programmes (Graaff & Kolmos, 2007) to meet these requirements can be addressed by different active learning approaches (Christie & de Graaff, 2017; Lima, Andersson, & Saalman, 2017). Several institutions of higher education have been addressing these requirements with project approaches to engineering education. Problem and Project-Based Learning approaches (Edström & Kolmos, 2014; Graaff & Kolmos, 2003; Helle, Tynjälä, & Olkinuora, 2006) have proven to be effective in making interdisciplinary connections between different subject matters, developing, in parallel, competences of project management, autonomy and communication (Lima, Dinis-Carvalho, Flores, & Hattum-Janssen, 2007; Powell & Weenk, 2003).

2 Design-based research (DBR)

To both develop and study this new model, an appropriate design and research methodology will be needed to guide the development work. Design-based research (DBR) was developed as an approach to 1) address learning theories, 2) to study learning in context, 3) to develop measures of learning, and 4) to contribute to new designs and learning theories (Reimann, 2011) and will be adopted for this development work. Kolmos (2015) identified four beneficial phases for DBR, as illustrated below, with elements for consideration.

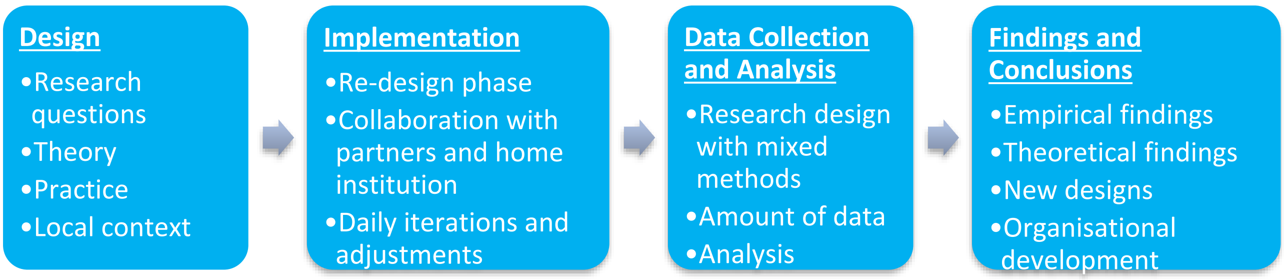

Figure 36. DBR Phases

These phases have been adapted and combined with the Andriessen (2007) dual purpose of DBR model. Andriessen's streams of Knowledge and Practice have been adapted as Research Design and Proram design, respectively, for this work as shown in Figure 2. For the case of the design of this new model, the stages of design will be: problem definition, creation of design objectives, identification of learning objectives for knowledge that will be necessary to accomplish the design objectives, planning (project management), and idea creation and selection. These steps are iterative and dynamic, whereby the design team will continuously ask whether the learning objectives align with the design objectives, whether the design objectives align with the problem definition, whether the plan is on schedule, etc. When reaching beyond the ideation stage, the research and design cycles become one. We will now briefly describe how the design cycle will apply this project of designing a new model of engineering education. This will be followed by application of the research cycle to the project and finally how the research and design cycles merge for this project.

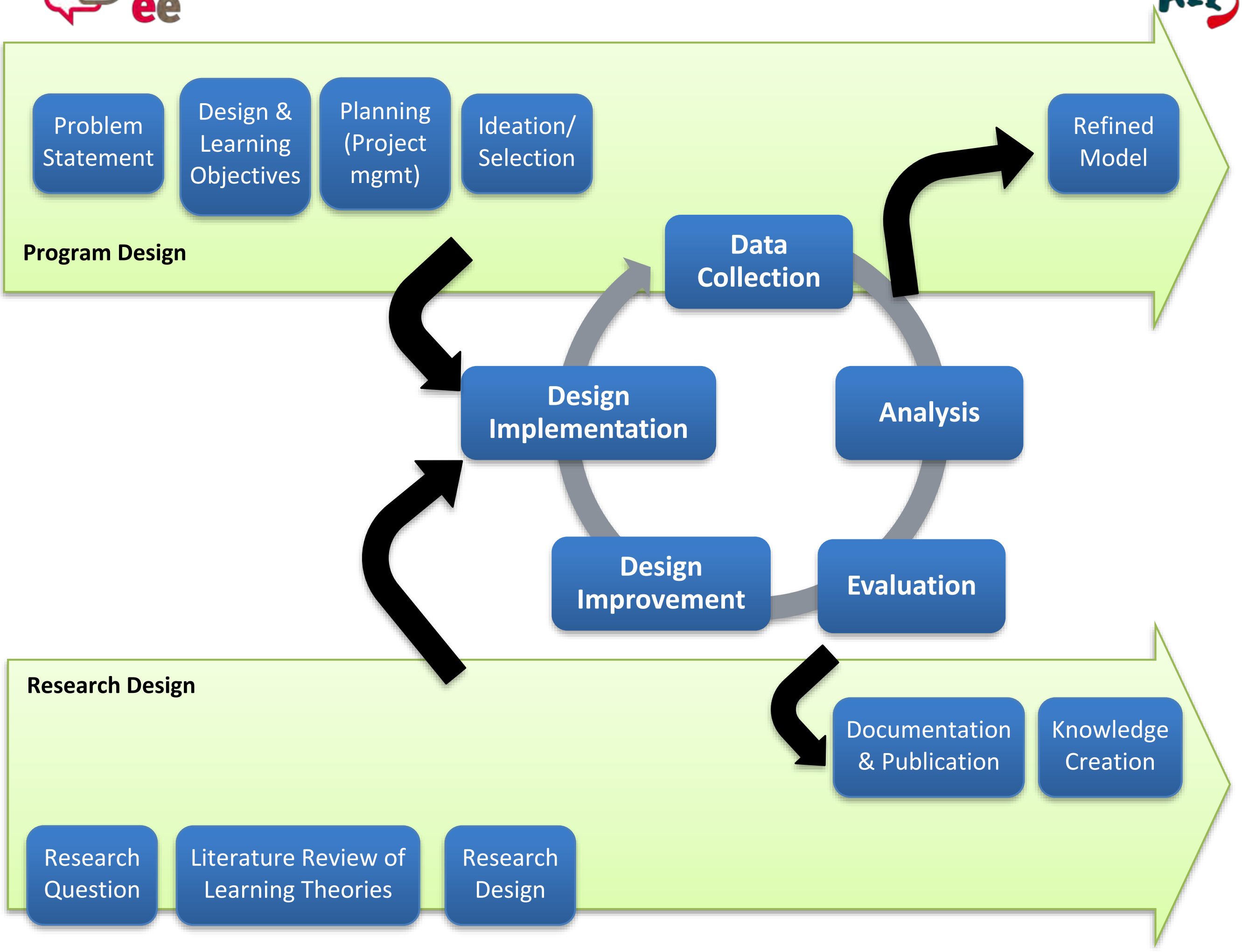

Figure 2. Adapted DBR Process Cycle

3 Implementing DBR methodology on a PBL pedagogy

The program design of the new PBL model of engineering education began in 2016. A small development team has been iterating through the problem definition, design objective, learning objective, planning, and ideation stages. Two idea generation workshops with teams from a variety of stakeholders have been held. Site visits have been made to potential collaborating institutions. National and international engineering education conferences have been attended with a focus to gather strategies and ideas for the new program. A conceptual model of the new program has been created. The next design steps are focused on benchmarking the potential student input pools and an external study verifying a financial model. From the research design perspective, the research questions have been identified and the learning theory literature review is underway. The next step is to develop a draft of the research design. Figure 3 below shows, in black text, the steps that are in progress and the steps in grey text that will unfold in the future. The next three sub-sections will summarize the current outcomes of the iterative work completed in each step and current model description.

New Engineering Education Model

Design Based Research Implementation

Designing the program	Designing the research
1. Problem definition	1. Research questions
2. Design objectives	2. Literature Review
3. Learning objectives	3. Research design
4. Project management	
5. Ideation and selection	

Combined design/research cycle

1. Design implementation
2. Data collection
3. Data analysis
4. Evaluation of results
5. Design improvement

Figure 3. Design-based research implementation steps

3.1 Applying DBR to the Problem Design

Problem definition:

Problem 1. There is a skills gap between the needs of industry and current engineering graduates across the country (Chan, 2017).

Problem 2. The costs of education put a burden on both the students (and their families) and society.

Problem 3. The "face" of engineering, particularly in the U.S., has not changed to represent the "face" of society. Many groups of people are under-represented in the profession compared to their representation in society.

Thus, a new model of engineering that addresses these problems is desired. The design statement is to:

> *Create a new model of engineering education that effectively produces "society-representative" engineers who possess the attributes needed to succeed in the emerging global economy of tomorrow in a way that is fiscally sustainable for students (and their families) and for society.*

Develop design objectives:

1. Identify student outcomes to be targeted by learning model.
2. Use appropriate theories of learning science and attributes of adapted models to create prototype new model to achieve student outcomes.
3. Identify audience of potential students and determine the appetite of the potential audience to partake in a new model of engineering education.
4. Perform economic analysis of prototype model to evaluation fiscal sustainability.

As the design continues to develop in sophistication, the design objectives will be modified accordingly.

Learning objectives:

To execute the actions of design usually requires substantial new learning in regards to works previously done by others (review of literature) and new emerging knowledge and technologies.

1. Seek models of success that have attributes that may be adapted to address the problems.
2. Seek learning theories that will underpin the new model.
3. Learn about the demographics of potential pools of incoming students.

4. Acquire knowledge on business plan development.

As the design continues, new learning objectives will emerge.

Project management:

A team of three engineers has developed and implemented a planning process that utilizes project management fundamentals.

Idea generation and selection:

See below in section 3.3 for the current results of the ideation and selection.

3.2 Applying DBR to the Research Design

Research questions:

RQ 1. How do engineering graduates develop in a co-op centric education?

RQ 2. How does a co-op centric model impact the financial status of the organization, student, and society?

RQ3. How does a co-op centric model impact the diversity and inclusion of the engineering profession?

RQ4. How does a new model of engineering education impact the economic development of NE Minnesota? (To be part of DBR, not to be included in PAEE paper)

Literature review:

Learning theories that define and support student development of engineering competences, models of financial impact, and literature on diversity in engineering are identified and resources are synthesized to develop hypothesis and research action plans.

Research design:

Data collection instruments are identified

3.3 Current draft of the new program design

3.3.1 Description of the new model

The new model takes advantage of three educational experiences.

1. Community college education (anywhere in the country)
2. The Iron Range Engineering models of professional and self-directed development
3. Co-operative education (co-op)

There are approximately 300 community colleges in the United States that offer associate degrees in engineering. The demographic of enrolled students at community colleges is considerably different than at universities. Community college students are more diverse ethnically, more gender diverse in the STEM fields, and are older, thus bringing more life experiences to their education. Among community college students, 51% are non-white, the average ages is 28, and 36% are first generation college students (American Association of

Community Colleges, 2017). Further, women earn 42% of the STEM degrees awarded at community colleges (National Science Foundation, 2017) .

The Iron Range Engineering (IRE) PBL program has developed unique and powerful models for creating professionally responsible, self-directed learners (Johnson 2016; Ulseth 2016). Over 10 published studies demonstrate the efficacy of these strategies and the advanced skill levels of IRE graduates (Guerra, Ulseth, & Kolmos, 2017) The strategies used at IRE will be a cornerstone for the new program.

Considerations for the new program begins with Co-op education, a long established practice in engineering (Selingo, 2016). In a co-op, students take a semester out of college to work as interns in engineering firms or industries. There are several engineering colleges in the United States that employ required co-op education (eg. Kettering University, the University of Cincinnati, and Northeastern University). In traditional co-ops, students receive only nominal credit (1-3) for the co-op experience and thus put off their graduation by a semester for each semester of co-op. Industries across the United States employ co-ops. They find the experiences as ways to both develop their own future workforce and to hold several month long interviews. Students find co-ops to often be the best part of their education. It is the place where all of the theory they have been using is finally put into use. Additionally, students earn a typically high wage while on co-op, very often more than $20/hr. This model empowers students to graduate from college with less college debt. Here are two excerpts from the University of Cincinnati website (www.ceas.uc.edu) that exemplify the co-op experience:

> *"Experienced-based learning isn't just real. It's smart. With a collective $57 million in annual co-op earnings, UC students graduate with less debt. It's one of the reasons we're ranked No. 1 in the nation for return on educational investment."*

> *"Cooperative education is an educational model in which students alternate traditional academic semesters with semesters spent working full-time in their chosen field. Co-op positions are paid and are offered by a variety of organizations all over the country and the world. Students complete between three and five co-op semesters prior to graduation. During each co-op semester, students complete an online course intended to help them focus on their academic and professional development. Co-op employers are also asked to evaluate student development and performance."*

The proposed new model recruits students from community colleges across the nation, upon graduating from their community college, to attend a 6-month intensive training experience period where they develop the high levels of self-directedness and professional responsibility necessary for success in a co-op placement and then they can either return to their home region or anywhere else in the country (or out) to complete a one-year co-op experience. After one year, they return to the home-base for one week to present and defend their learning. Upon successful defense of this learning, they go back to industry for a second year of co-op placement. After the second year, the students return for another round of exams and presentations. Successful defense at this point will result in the awarding of a bachelor's of science in engineering. Figure 4 is a line diagram portraying this model.

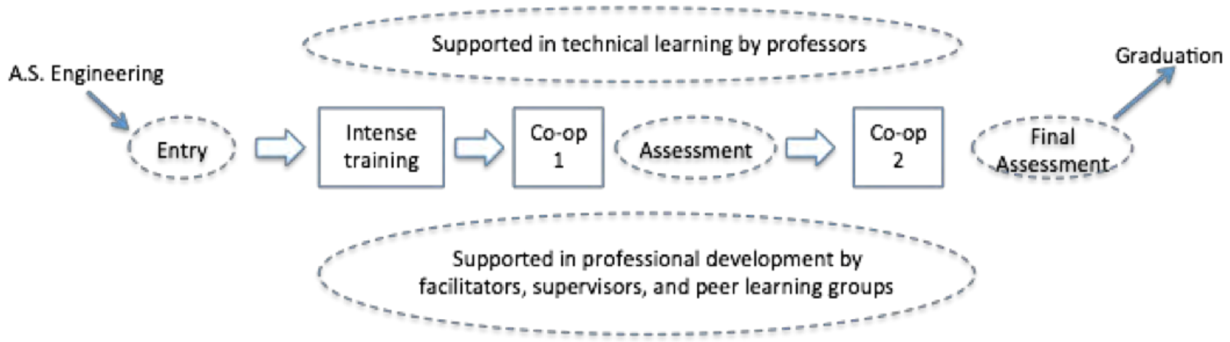

Figure 4. Graphic depiction of new model

The students will be empowered to learn technical content by their professors who provide on-line technical learning modules and frequent personal feedback. Students will be empowered to develop as professional people and creative designers by engineers from practice (facilitators) who meet with the students weekly (electronically) to give feedback on their development and on their design and professional assignments. This technical, professional, and design learning that happens during the co-ops is a departure from all other US co-op engineering models. This learning is what enables the students to earn full credit towards graduation for successful co-op completion as compared to other US institutions where full credit towards graduation is not awarded.

In 2016, Charles Sturt University (CSU) in Bathurst, Australia began their co-op based engineering education model (Lindsay and Morgan, 2016). The Charles Sturt model does provide substantial learning during co-op as well as full credit towards graduation. The new model described above is an adaptation of the CSU model with influences from other co-op models. In summer 2016, the founders of the CSU model visited IRE to identify unique attributes of the IRE model that could be adapted for CSU. Since that meeting, IRE has been in close contact with CSU for sharing current and future engineering education practices.

3.3.2 Compelling attributes of the new model

Adaptation of effective learning strategies created in the Iron Range Engineering model - In the 8 years of IRE operation, distinct models of learning for professional development, design, and self-directed were developed. These strategies include: highly developed model of reflection, professional development curriculum, professional development plans, design and project management curriculum, technical development plans, seminar series, and an extensive communication curriculum. All of these curricular strategies are adaptable to the new model for effective engineering student development.

Creation of more effective engineering graduate - industries have long been dissatisfied with graduates of traditional engineering programs. This dissatisfaction stems from the inability of new graduates to navigate the professional world. At Iron Range Engineering, they have addressed this deficit by allocating substantial student time to both the application of technical knowledge in realistic settings and the practice of professional skills [our book]. The implementation of both the co-op experiences and the IRE strategies will provide the more fully developed and effective engineering graduate sought after by industry.

Very low net cost to the student - students will pay $11,000 USD per semester for five semesters (intensive training plus two years of co-op) for a total of $55,000. The will typically earn $20/hr for the 24 months of co-op for a total of ~ $80,000 gross. Students who are able to live a college student existence during this timeframe will be able to graduate with near zero debt for the co-op portion of their education.

4 Conclusion and Next steps

A new model of engineering is being developed. Utilizing the principles of PBL and the strategies developed in the Iron Range Engineering PBL program, the new model will combine in-situ learning of engineering skills in through unique university-industry partnerships. A design-based research approach is being undertaken to use research principles to iteratively feed knowledge to the development of the model and to greater body of knowledge.

The next major steps are to focus on developing the research design process for the proposed model and one more iteration of the program design before implementation. For the first cohort of students to experience the new model, a process of data collection, data analysis, evaluation of results, and a process for continuous design improvement will be identified and implemented. This pilot group will be recruited from ~25 community colleges from across the U.S. Recruitment has begun and initial interest levels are high. The target sample size is 25-30. This size is approximately one-third the size of the proposed steady-state operation. This size was selected to allow for flexible adaptation of processes during the initial implementation. The pilot is planned to start in July 2019.

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Designing and implementing interdisciplinary projects in a Systems Engineering Master programme

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Abstract

Interdisciplinary projects (IP) carried out by teams of students have been recognized as an important approach for learning in several fields and at several levels of education. In higher education, it can be an important drive for student learning motivation and an advantage for students when entering the working marketplace. The experience acquired while developing IP gives students technical and transversal competences highly relevant for employment but above all give students confidence and a competitive advantage. This paper aims at describing and discussing an experience in carrying out interdisciplinary projects in the context of a System Engineering Master (SEM) programme. First we explore the SEM programme philosophy and organization focussed on IP-based learning and then, for a particular IP course unit of the SEM, the dimensions of project design and specification, project interdisciplinarity, teaching team organization, support to students, project evaluation and individual students' assessment. The authors argue that the IP learning model adopted in the case here reported is a good example of an IP-based learning at a master degree level.

Keywords: Interdisciplinary Projects; Design Projects; Project-Based Learning; Engineering Education; Systems Engineering.

1 Introduction

During the last years, there has been an increased interest in Active Learning in Engineering Education (Lima, Andersson, & Saalman, 2017). The educational approaches developed under the umbrella of Active Learning, promote the creation of an environment where the student has the opportunity of being engaged in the learning process, developing autonomy to select some paths of his own learning. This environment should give an adequate context for learning, aligned with professional needs. Such a context will contribute for giving a meaning for learning. In this way, students will understand the "why", and will reflect on "what" they are learning (Bonwell & Eison, 1991; Christie & de Graaff, 2017; Prince, 2004). These approaches have been evaluated as more effective for the learning process (Freeman et al., 2014).

Different approaches of Active Learning have been developed over the years and one of the most implemented in Engineering Education is Project-Based Learning (PBL) (Lima, Andersson, & Saalman, 2017). In project-based learning, teams of students develop a project during a predetermined period to solve open problems related to the professional practice. During this period, students simultaneously develop the project and the required competences (Edström & Kolmos, 2014; Graaff & Kolmos, 2003). In several setups of PBL, the technical competences related to a specific professional area are conceptually supported by courses on which they are enrolled in this period. During such period students develop an interdisciplinary project through the integration of the different courses' contents (Alves et al., 2016; Lima, Dinis-Carvalho, Flores & Hattum-Janssen, 2007; Powell & Weenk, 2003). Additionally, the students acquire transversal competences, e.g. teamwork, autonomy and creativity, intentionally required by the project work and the professional practice (Lima, Mesquita, Rocha, & Rabelo, 2017).

The number of works explicitly referring the development of interdisciplinary projects in master programs educational level is scarce. This work aims to contribute for the engineering education field, describing an interdisciplinary project approach implemented in a Systems Engineering Master programme. Additionally, the authors present a discussion about the main contributions of this approach.

The paper is organized in six sections, including this introduction where the paper objectives are also referred. The Systems Engineering Master programme is briefly presented in the second section. One of the interdisciplinary projects course units is overviewed in the third section, followed by the fourth section that presents the project design and specification developed by the students in the PBL context. Section five presents the students assessment criteria and process. Finally, section six presents some final remarks.

2 The Systems Engineering Master programme

The Systems Engineering Master (SEM) programme at University of Minho, Portugal is a two-year master programme, under the responsibility of the Department of Production and Systems. Table 18 represents the programme organization. The SEM is centred on several curricular units (courses) aimed at giving students competences required by the marketplace as Systems Engineering professionals and for being able to carry out with success the SEM master dissertation. This is carried out partially in the 1st semester of the 2nd year with full dedication during the 2nd semester. In the first semester of the 2nd year, students have also an intensive and focused education on research methodologies and tools. This is essentially concerned with ensuring that students learn to choose the right research methodologies and methods to carry out research projects and to access the right resources, including bibliography, that are necessary. Additionally, they learn and practice to fully develop and establish plans for industrial research projects that culminate with each student developing the project plan for his or her own master dissertation, under the guidance of a teacher on the technological domain of the dissertation and the teaching staff on research methodologies. Then, after project plan approval by the SEM programme direction, with the agreement of all teaching staff of the department, students carry out their projects under the guidance of one supervisor or, exceptionally, two, dependent on the technical skills required by the project. A typical case when two supervisors may be needed is when a project falling in a technological domain requires complex statistical analysis or computer simulation.

Table 18. University of Minho - Systems Engineering Master programme organization structure

	Curricular Unit (CU)	ECTS
Year 1		60
S1	Systems Simulation	5
S1	Manufacturing Planning and Control	5
S1	Integrated Project 1	5
S1	Option 1	5
S1	Option 2	5
S1	Integrated Project 2	5
		30
S2	Systems Analysis	5
S2	Logistics	5
S2	Integrated Project 3	5
S2	Option 3	5
S2	Option 4	5
S2	Integrated Project 4	5
		30
Year 2		60
S1&S2	Master Dissertation	45
S1	Research Methods	5
S1	Option 5:	5
S1	Option 6	5
	Total	120
ECTS – European Credit Transfer and Accumulation System. Si- Semester i		

The SEM programme has run now for 10 consecutive years having had a structure adjustment two years after starting in the school year 2008/09. This adjustment enriched the programme curricula through a larger focus on student teams' interdisciplinary projects with a consequent increase in the programme design configuration flexibility. This was achieved by increasing the number of interdisciplinary projects, reducing its duration from one year to one semester and by focussing each one of them on two, instead of four, related or complementary curricular units (CU). The range of CU for choice was carefully aligned with the overall learning objectives and planned learning outcomes of the SEM. The restructuring improved focus and control over the projects for students and teachers alike. The adjusted programme organization is shown in Table 18. This adjustment was driven by the perception that, on one hand, project oriented approaches seemed, and had been confirmed by previous research, more motivating for students and having positive impact on students learning (Fernandes, Mesquita, Flores, & Lima, 2014; Prince, 2004), and, on the other, giving students an advantage in the working marketplace resulting from its practical experience, working autonomy and transversal skills acquired from carrying out projects, developing reports and presenting work done and results, all of which are assessed by the teaching staff team.

The SEM programme design configuration flexibility, based on several specialization topics was a natural requirement faced with the diversity of jobs that students are called to fill in the marketplace and the somewhat diverse backgrounds of students enrolled at the SEM. Actually, SEM students are graduated young students and professionals, mostly from engineering, with a focus on computer science related engineering, but also from sciences and management. Students with bachelors in Mathematics and even in Physics have also joining the SEM. SEM students realize that the SEM competences offered, together with their previous acquired competences, give advantage edge in the working marketplace.

3 Interdisciplinary project overview

One of the CU of the SEM programme is called Integrated Project 1 (IP1). IP1 is a curricular unit in a form of an interdisciplinary project, with its own planned learning outcomes which depend on, complements and integrates learning outcomes of two other courses, namely Systems Simulation (SS) and Manufacturing Planning and Control (MPC). IP1 aims at the application of knowledge on these rather different domains that are necessary to put together when the objective is to apply and understand the workings and behaviour of different strategies and methods for managing manufacturing systems. This application and understanding is critical for practical implementation of such strategies and mechanisms and can be obtained by system simulation studies of manufacturing systems' operation. This project approach involving these three courses is a consequence of the interdisciplinary learning process model fomented by the main learning strategy adopted in the SEM, based on projects involving typically two complementary or interrelated domains and studied at advanced level in two curricular units.

In a summarized way, learning outcomes for the three courses, including IP1, are:

Systems Simulation:

- Understand the basic concepts of discrete-event simulation.
- Understand the nature and application of discrete-event simulation and know how to experiment with it.
- Use experimental design techniques and related statistical tests.
- Make appropriate modelling simplifications concerning the level of detail and the degree of abstraction.
- Develop a working knowledge of a discrete-event simulation software packages, such as SIMIO™ and Arena™.
- Interpret the meaning of simulation results, and make evidence-based recommendations for the design and operation of a system of interest.

Manufacturing Planning and Control:

- Correctly communicate, orally and by writing, in the technical language of MPC.
- Identify and describe the main functions of MPC in any manufacturing organization.

- Identify, describe and apply important manufacturing methods and techniques for managing manufacturing operations for different market demand environments.
- Identify, describe and use important measures of manufacturing performance and align them with market demand environments.

Integrated Project 1 (IP1):

- Identify methods and mechanisms for Manufacturing Planning and Control (MPC) in different production environments.
- Apply discrete event simulation to design, analyse and improve the performance of MPC methods.
- Build simulation models of manufacturing systems and the design experimental setup to study the systems' operation and the performance behavior of different MPC methods.
- Interpret and analyse the simulation results based on their validity, meaning and statistical significance, and draw conclusions about the systems' behaviour.
- Work in groups to solve problems cooperatively and communicate effectively.

As common in interdisciplinary projects, IP1 learning objectives are achieved based on projects that involves teams of students.

4 Project design and specification

One could go about several ways to specify students' projects (Gommer & Rijkeboer, 2010; Holgaard, Guerra, Kolmos, & Petersen, 2017; Moreira, Mesquita, & Hattum-Janssen, 2011; Powell & Weenk, 2003, Alves & Leão, 2015). Nevertheless, constraints related to objectives and learning outcomes must be taken in full consideration. To do that, in this case, to ensure that such objectives and outcomes could be delivered and that good control of project development and evaluation could be achieved, the teachers involved in managing and supervising the student's projects decided to elaborate themselves a project specification with variants for each team of students based on a common project specification framework.

4.1 A common project specification framework

There are a few constraints or requirements that should be considered for designing the project of each team of students that, in the case of IP1, are described below.

Firstly, probably the most important constraint or requirement is to ensure that the planed learning outcomes can be achieved. Another is to devise criteria and a process for student assessment that leads to a fair evaluation of student work and learning achievements. This must obviously be related with the student contribution for meeting project objectives and output requirements, such as for results discussion, work presentation, project report and communications or publications. A third constraint or requirement is ensuring that workload per team, and mainly per student, should be as identical as possible and compatible with the planned workload for the course. This include, 45 hours in the class room, i.e. simulation lab, with the support and guidance of teachers, and 95 hours of work that each student must manage according tasks allocated and needs for student individual study and interaction within the team, together with some complementary support of teaching staff. The intensity of interaction between teacher and students very much depends on the expressed needs and requirements of students during project development. The teacher can also, when thought required, ask for all students' attention to clarify issues thought to be critical or particularly important for the good understanding of the IP1 topics and for the development and progress of the IP1 projects.

The fourth and a logical constraint or requirement, based on the previous ones referred, is to think of projects that should implement the same learning process on a common framework, providing equivalent learning content and, at the same time, ensuring project differentiation for each students' team. Although an objective difficult to meet it can be made possible acting upon both, variables that characterize the production and operational environment and variables that can be experimental factors in systems simulation studies of manufacturing systems management. Suitable combination of these variables will lead to a diversity of projects based on the same learning process and framework, having a degree of modelling and analysis complexity very much equivalent and therefore requiring similar amounts of workload. Examples of experimental factors used in project specification are:

- The MPC mechanism. This has been the main experimental used in the IP1 factor and can be studied at several levels such as TKS (Toyota Kanban System) (Sugimori, Kusunoki, et al., 1977), DBR Drum-Buffer-Rope (DBR) (Goldratt, Fox, 1986) and CONWIP (CONstant-Work-in-Process) (Spearman, Woodruff & Hopp, 1990);
- The material flow control strategies. These refers to additional experimental factors that students may add to the problem, such as pool sequencing rules and the dispatching rules that govern the release of jobs into the systems and the work flow through the system, respectively.

Other variables for characterization of production system and operational environment, which generally make part of the problem description, include:

- The Manufacturing Approaches for Satisfying market Demand (MASD), i.e. Make-to-Order (MTO), Make to Stock (MTS) and hybrid MTO-MTS;
- The Manufacturing Systems Configurations (MSC): Job Shop; Flow shop; General Flow Shop, Flexible Flow Shop and flexible versions of these obtained by replicating all or some workstation types (Pinedo, 1995).

Table 19 shows, for two school years, according to the common project specification framework above referred, the several levels of the experimental factor, named mechanism for MPC, that were chosen by student teams for their project specification. This choice together with the choice of other variables for experimentation or system operation, lead to complete or partial differentiation of the project specifications of each team. Thus, e.g., when frequency of choice, in table 2, is larger than 1 (one) there is sharing of this experimental factor level by a number of groups equal to the frequency of choice. This information shows that there is a relative degree of freedom and autonomy of teams to define their own project, which make a contribution for the flexibility of the project.

Table 19. An experimental factor contributing for differentiating the student teams' projects.

Mechanism for MPC (experimental factor)	**Student teams' factor levels choices 2014/15**						**Student teams' factor levels choices 2015/16**						
	T1	T2	T3	T4	T5	Frequency of choice	T1	T2	T3	T4	T5	T6	Frequency of choice
BSS			1			1					1		1
CONWIP -MTS			1			1			1		1		2
TKS - Milkrun						0							0
TKS			1			1			1		1		2
MPR-CAP						0	1					1	2
POLCA				1	1	2	1	1					2
GPOLCA		1				1		1		1			2
GKS	1	1			1	3	1	1				1	3
WLC	1					1				1		1	2
CONWIP-MTO		1		1	1	3				1			1
Two Bin						0			1				1
DBR	1					1							0
Ti , i=1,...6 is the student teams representation.													

4.2 Organization of student's teams and project allocation

The size of students' teams on PBL are typically between 5 and 9 students depending on project complexity and size. Due to the controlled nature and size of the projects, in our case we realize that teams of five students meet several requirements including, expected workload per student, potential for collaboration among students and manageable number of teams in the class. So, as a basis for team organization we proposed teams of five students. The team size may vary slightly according the number of students attending the IP1 CU aiming, however, as much as possible, to teams of the same size, which are self-organized.

All teams develop system simulation models for evaluation of the performance of different manufacturing control systems (MCS) for operation of manufacturing systems. Each team carries out a different project, focussed on building a systems simulation model and using it for studying the application and performance behaviour of MCS. Each project is based on a common framework but resulting, as above said, from different combinations of system configuration and operation variables and experimental factors, used in the system simulation study related to each project. As a matter of easing control over and verification of simulation results some teams may carryout projects with partial interception of specifications and objectives. In this case independently of the modelling alternatives chosen and different models used, the teams that share the same specifications must arrive to the same simulation results. This partial sharing has a positive effect on the learning process since some teams can interact and compare their work solutions against those of other teams. Moreover, this makes easier the process of analysing and verifying of project results, both for students and teaching staff alike, and eases also the task of project evaluation. Additionally, we may also be concerned with studying manufacturing control influenced by the priority of order release and or order dispatching. So, using different manufacturing systems' platforms, formed by suitable combination of production and operational environment variables, such as those grouped under the headings of MSC and MASD above referred, we can develop experimental work on the performance of MCS methods and mechanisms using system simulation models developed by the IP1 course students' teams.

In this way we meet the third and fourth constraint or requirement identified in the previous section and pave the way for meeting the first and, at the same time, devising suitable student assessment criteria and process.

5 Students assessment criteria and process

This section describes the process of assessing both the project and individual students.

5.1 Assessing the project

Before going on describing the process and criteria for students' assessment we must describe the role of the teaching staff teams involved in the IP1 course and how projects themselves, not students, are evaluated. Thus, all the teachers responsible and collaborating on the student learning process, in both courses instrumental to IP1, are involved in helping and guiding students mostly, but not only, during course sessions, to achieve IP1 objectives, namely to develop successful projects, and achieve learning outcomes. Moreover, they are agents involved in assessing the achievement of the learning outcomes and student involvement and contribution for the development, output and quality of the projects.

Thus, IP1 projects assessment mostly results from the soundness of both model building and the simulation results obtained. The capability for written and oral presentations of the work and results, together with model verification and analysis of simulation results, are also important components for assessment of project quality and value, having into account the objectives and learning outcomes. Based on this, the assessment of the IP1 projects is determined by the two teaching teams responsible for each of the two instrumental courses, i.e. Systems Simulation and Manufacturing Planning and Control. All referred variables are weighed to reach a mark for the project itself. The weight of the view of each of the two teams on the projects assessment is 50%. This assessment is central to individual student's assessment on the IP1 course and is also used for assessing the Systems Simulation itself, but not the MPC. This is evaluated independently from IP1. These different views of using the project assessment on the assessment of the instrumental courses seem very logic to the teams, having into account their different instrumental nature to IP1.

5.2 Individual students' assessment

The actual method for individual student assessment on the IP1 CU is the result of a smooth evolution of the assessment process that has been implemented as an ongoing process of adaptation and adjustment aimed at improving individual assessment of students. Individual marks of students, based on project work and learning achievements must be fare. Achieving this is not easy with teams of five students or more working together in the same project and with the variety of assessment variables involved. So, mechanisms must be established that ensure fairness on individual student assessment. Although many strategies and approaches have been devised (Powell, 2004) in our case we use four dimensions of assessment:

1. The first one is based on the project assessment itself, as referred in previous section.
2. The second dimension is based on students' self-assessment.
3. The third results from the perception of the teaching teams relative to the contribution of each individual student in the team to the value of the project.
4. The final mark of the IP1 CU for the individual student is based on the assessment carried out under the scope of the instrumental courses of the project, namely in our case, SS and MPC, having into account the result from applying the three previous dimensions of assessment.

The first, second and third dimensions of student's assessment in the IP1 course are all concerned and related with the interdisciplinary project itself. The fourth is dependent on student individual performance on the two instrumental courses supporting the interdisciplinary project, is our case, MPC and SS. Thus, project assessment is first carried out by the teaching team, accomplishing the first dimension of assessment, who establishes the marks for the project, having into account several aspects related with the project development and results, as referred in the previous section. These marks, are multiplied by the number of students in the team to determine the size of the "cake" that the students, in a self-assessment process, must divide by themselves, in a fair and democratic manner, based on their perception of the contribution of each of the team members for the project value and for the work and ideas during project development. Limits are imposed by the teaching teams to the maximum and minimum marks, i. e. the size of the "piece of cake", which a student in the team can have. This results from a small, variation around the mean that the teaching teams, based on their experience and context, consider fair. For the student's self-assessment, in line with the experience of other authors (Alves et al., 2012), the teaching staff suggests, as a guidance to students, some criteria, such as degree of participation or involvement in carrying out the project and reporting the results and contribution to modelling or problem solving.

In the third dimension, if the teaching teams agree, based on their perception during project development and results presentation that the marks for a student are unfairly high, or low, they marginally adjust the marks of that student. Therefore, this may lead to the adjustment of the marks of other students in the team, since the "cake" size is unchangeable. Although this adjustment is formally part of the evaluation criteria our experience is that this rarely is necessary to apply.

The result of the application of the three first dimensions of individual student assessment results in the individual student marks, in the zero to twenty scale, related with the interdisciplinary project.

The application of the fourth dimension leads us to an individual assessment on the IP1 CU. Thus, having into account the result from applying the three previous dimensions of assessment, we establish the student individual marks for the IP1 based on the weight contribution of the student performance on the two IP1 instrumental courses and that for the interdisciplinary project. Thus, MPC individual assessment enters as a weight of 15%. The student performance on individual SS assessment tests and course work contributes with another 15% to the individual assessment of the IP1 course. Therefore, the individual assessment mark for each student, in the IP1 course, weights the result from the first three dimensions as 70% and the 30% remaining from the fourth, i.e. 15% from each of the two instrumental courses. This combination seems, to the teaching team, a good balance between the individual students work carried out as team members and the work carried out individually in the Manufacturing Planning and Control and Systems Simulation courses.

We are not sure that the weights here referred are the fairest. Recognizing that knowing what combination is the fairest is not an easy task, we believe that this is a reasonable combination of weights based on the considerations made above. However, we also recognize that further study should be done on the procedure for individual student assessment.

6 Final remarks

Interdisciplinary projects (IP) have been advocated as an approach that tends to advantageously favour students learning and the acquisition of transversal competences. This, are nowadays seen as an advantage to enter the working marketplace. Having this into account the Department of Production and Systems of the University of Minho, from Portugal, decided to implement a new SEM programme structure based on interdisciplinary projects. Within this structure we describe the implementation of an IP based SEM course, referred as Integrated Project 1 (IP1), and present a framework structure for students' projects design and evaluation adopted in this course. Moreover, we discuss the student individual assessment, based on four dimensions, including self-assessment and a share contribution from the instrumental courses to the IP1, namely Systems Simulation and Manufacturing Planning and Control.

One important remark is the required fairness of course workload, project complexity, project assessment and individual student assessment that interdisciplinary projects developed by teams of students need to meet. This is a difficult problem that nevertheless must be solved if the IP based learning process is to be adopted. The solution described, in the context of the IP1 course, we believe to be a good example that can be adapted to many other contexts, certainly in engineering courses. Probably the most sensible aspect to deal with is course individual assessment fairness. We present a methodology that we believe meets this fairness requirement. However, we think that there is still room for improvement and, therefore, we intend to make further adjustment and adaptation aligned with the dynamics of the learning and assessing requirements observed.

As a final remark we should emphasize that, under the interdisciplinary projects in the context of IP1, students were encouraged to publish work related with project development and results and, in the last few years, a few papers (André et al, 2014; Rocha et al., 2015; Gomes et al., 2016; Barros et al., 2016; Silva, et al., 2017) were presented to scientific events and published in conference proceedings, books and journals.

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Problem-Based Learning adapted to the organizational context for the development of management skills in micro and small enterprises

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Abstract

Micro and small companies in the last years have presented a notable representation in the Brazilian economy and potential in the generation of income and employment, however, although they have notoriety and growth in the economic and social spheres, they still have a high mortality rate due to difficulties and challenges related to its implementation, management and maintenance of the business, due to the lack of planning and management skills. With the frequent changes in the competitive landscape, it is important that micro and small enterprises are constantly in the process of adaptation and learning, requiring managers to perform their skills efficiently and develop new skills. In view of the above, this article aimed at the development of management skills of micro and small entrepreneurs, characterized as one of the challenges faced by the managers of the companies to stay in the market. To do this, the Problem-Based Learning (PBL) method was used, adapted to the organizational context, with the purpose of helping to solve problems and, thus, to provide improvements regarding the managerial characteristics of each participant in the group. The strategy used in this research was the action research, since it had the direct participation of all those involved who adopted an active stance in the processes of change in organizations through weekly meetings. Among the results achieved, learning at the organizational, collective and individual level, the development of management skills, and evidence that the ABP methodology adapted to the organizational context proved to be efficient in the development of management skills in micro and small enterprises and that has relevance for the improvement of the management of micro and small companies, given that it has brought benefits such as improvements in work relations, customer service, employee motivation and managers' abilities to run the company.

Keywords: Micro and small enterprises; Skills development; Problem-Based Learning.

Aprendizagem Baseada em Problemas adaptado ao contexto organizacional para o desenvolvimento de competências gerenciais em micro e pequenas empresas

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Resumo

As micro e pequenas empresas nos últimos anos têm apresentado notória representatividade na economia brasileira e potencial na geração de renda e emprego, no entanto, apesar de possuírem notoriedade e crescimento nos âmbitos econômico e social, ainda possuem alta taxa de mortalidade devido a dificuldades e desafios referentes à sua implantação, gerenciamento e manutenção do negócio, decorrente da falta de planejamento e habilidades gerenciais. Com as frequentes mudanças no cenário competitivo, é importante que as micro e pequenas empresas estejam constantemente em processo de adaptação e aprendizado, exigindo que os gestores desempenhem suas habilidades de forma eficiente e que desenvolvam novas competências. Diante ao exposto, este artigo objetivou o desenvolvimento das competências gerencias de micro e pequenos empreendedores, caracterizado como um dos desafios enfrentados pelos gestores das empresas para a permanência no mercado. Para tal, fez-se o uso do método da Aprendizagem Baseada em Problemas (ABP), adaptado ao contexto organizacional, tendo como propósito auxiliar a resolução de problemas e, assim, proporcionar melhorias referentes às características gerenciais de cada participante do grupo. A estratégia utilizada nesta pesquisa foi a pesquisa ação, pois contou com a participação direta de todos os envolvidos os quais adotaram uma postura ativa nos processos de mudança nas organizações por meio de reuniões semanais. Dentre os resultados alcançados destaca-se a aprendizagem no nível organizacional, coletivo e individual, o desenvolvimento das competências gerenciais, além de evidenciar que a metodologia ABP adaptada ao contexto organizacional mostrou-se eficiente no desenvolvimento das competências gerenciais em micro e pequena empresas e que possui relevância para a melhoria da gestão de micro e pequenas empresas, tendo em vista que trouxe benefícios como melhorias nas relações de trabalho, no atendimento ao público, na motivação dos funcionários e nas habilidades dos gestores em conduzir a empresa.

Palavras-chave: Micro e pequenas empresas; Desenvolvimento de competências; ABP.

1 Introdução

As mudanças das últimas décadas têm causado impactos de forma significativa nas estruturas das organizações, quanto à forma de atuação e, consequentemente, nos seus resultados. Este ambiente passou a exigir das organizações, inovação constante da estrutura, dos produtos, serviços, bem como, maior flexibilidade na forma de administrar a organização como um todo, destacando assim, novos modelos de gestão, tornando as organizações mais dinâmicas e competitivas, aspectos decisivos para a manutenção da sua sobrevivência (Silva, 1996).

Cacenote (2007), destaca que as Micro e Pequenas Empresas - MPEs possuem características distintas no modelo de gestão, tomada de decisão, políticas de recursos humanos, sendo que, em muitos casos, o indivíduo não tem possibilidade de participar da mudança organizacional, limitando sua capacitação, apresentando necessidade de buscar mais conhecimento administrativo. O bom gerenciamento é imprescindível, havendo a necessidade de que os gestores realmente coloquem em prática as suas habilidades gerenciais, como liderança, planejamento, trabalho em equipe entre outras competências que são fundamentais para o sucesso do empreendimento.

Pelissari (2007), aponta que as mudanças no cenário competitivo e a necessidade constante de capacitação do quadro gerencial, para acompanhar e gerar essas mudanças, propõem que a questão das competências vem despertando o interesse tanto da área acadêmica como gerencial.

Esta pesquisa objetivou desenvolver competências gerenciais de Micro e Pequenas Empresas situadas no Município de Marabá, estado do Pará, por meio do uso da Aprendizagem Baseada em Problemas adaptado ao contexto organizacional, buscando a obtenção de melhorias e maior rendimento no que diz respeito ao processo de produção e gerenciamento nas gestões de planejamento, projetos, qualidade, dentre outros segmentos, de acordo com as particularidades e problemáticas de cada empresa participante da pesquisa.

2 Referencial Teórico

Abaixo, apresenta-se as definições e conceitos que serviram de embasamento teórico necessário à pesquisa, são apresentados características das micro e pequenas empresas, o desenvolvimento de competências e a Aprendizagem Baseada em Problemas.

2.1 Micro e pequenas empresas

A atenção sobre os pequenos negócios está crescendo dia após dia, a maioria dos países está direcionando investimentos para esse setor porque reconhece a importância exercida pelas Micro e Pequenas Empresas (MPEs) na geração de empregos e negócios, distribuição de renda e criação de valor, importantes para o desenvolvimento da economia de qualquer país (JUNIOR e PISA, 2010).

As pequenas empresas surgiram, entre outros motivos, devido às novas oportunidades de mercado, como consequência da crescente exigência dos consumidores. As pequenas empresas atendem necessidades específicas denominadas de "nichos" de mercado, não explorados pelas grandes empresas, o que garante sua sobrevivência. Um dos "nichos" de mercado a serem explorados pelas MPEs são os processos de manufatura, da logística reversa, de reciclagem de produtos, inerentes ao momento atual em que se encontra nosso planeta: perante exigências de adaptação dos sistemas produtivos à futura escassez de recursos não renováveis e às alterações do clima (LUSTOSA *et. al.*, 2008).

No Brasil, não existe uma nomenclatura única para a classificação do porte de uma empresa. De acordo com a lei geral das MPEs (Lei Complementar 123/06) uma microempresa deve ter faturamento anual de até cerca de US$ 150 mil e a de pequeno porte cerca de US$ 1.5 milhões. Já o SEBRAE classifica o porte das empresas de acordo com número de funcionários, sendo menos de 9, Micro, de 10 a 49, Pequena, de 50 a 99, Média e, acima de 100, Grande porte (GOMES *et. al.*, 2013).

2.2 Desenvolvimento de competências

Segundo Hanashiro *et. al.* (2008), o desenvolvimento de competências parte do processo da aprendizagem, no nível individual ou organizacional, incorporadas através dos processos e rotina de uma organização, se caracterizando como um conjunto de recursos e habilidades adquiridas ao longo do tempo. Aprendizagem pode ser assim pensada como um processo de mudança, provocado por estímulos diversos, mediado por emoções, que pode vir ou não a manifestar-se em mudança no comportamento da pessoa (FLEURY e FLEURY, 2001).

Fleury et. al. (2002), destaca que o conceito de competência é pensado como o conjunto de conhecimentos, habilidades e atitudes (isto é, o conjunto de capacidades humanas), que justificam uma alta performance, acreditando-se que as melhores performances estão fundamentadas na inteligência e na personalidade das pessoas. Um aspecto fundamental para desenvolvimento de competências é a apropriação do conhecimento (saber) em ações no trabalho (saber agir). Acredita-se que, por meio do desenvolvimento dos elementos (conceitos, princípios e práticas) de aprendizagem organizacional, seja possível desenvolver as competências, viabilizando práticas condizentes como conhecimento adquirido. Destaca-se que é nesse momento que o desenvolvimento de competências agrega valor às atividades e à organização (BITENCOURT, 2005).

Para Leme (2005), gestão por competências é o processo de conduzir os colaboradores para atingirem as metas e os objetivos da organização através de suas competências técnicas e comportamentais. De acordo com Carbone et. al. (2009), para a identificação de competências é necessário seguir algumas etapas, que vai desde a concepção das estratégias da organização, possíveis definições de indicadores de desempenho e identificação das competências através do mapeamento de competências organizacionais ou humanas. O mapeamento objetiva identificar o gap ou lacuna de competências, isto é, a diferença entre as competências necessárias para concretizar a estratégia formulada e as competências internas já disponíveis na organização (BRANDÃO e BAHRY, 2005).

Os passos seguintes compreendem o planejamento, a seleção, o desenvolvimento e a avaliação de competências, buscando minimizar a referida lacuna, o que pressupõe a utilização de diversos subsistemas de recursos humanos, entre os quais, recrutamento e seleção, treinamento e gestão de desempenho (BRANDÃO e GUIMARÃES, 2001).

2.3 Aprendizagem Baseada em Problemas - ABP

O aprendizado é gerado por um exercício de ação- reflexão, num processo dinâmico e proativo, no qual as situações que se apresentam são consideradas num patamar diferentes de entendimento e conhecimento. Kalatzis (2008) aponta que a ABP enfatiza a aprendizagem em vez da instrução, além de estar centrada no aluno. O método permite que o estudante aprenda a partir de um problema proposto, real ou simulado, interagindo, obtendo dados, formulando hipóteses, tomando decisões e emitindo julgamento. Assim o aluno torna-se responsável por sua própria aprendizagem.

O PBL é uma metodologia que abrange muitas variantes. Muitas atividades educacionais poderiam ser caracterizadas como aprendizagem baseada em problemas, tais como projetos e pesquisas. No entanto, define-se PBL, como uma metodologia de ensino-aprendizagem em que um problema é usado para iniciar, direcionar, motivar e focar a aprendizagem, diferentemente das metodologias convencionais que utilizam problemas de aplicação ao final da apresentação de um conceito ou conteúdo. É esta a principal característica do PBL e o que o diferencia de outras formas de aprendizagem ativa, colaborativa, centrada nos alunos, voltadas para a pratica ou fundamentadas em casos de ensino. Outra característica importante do PBL é o fato de contemplar o trabalho de grupos pequenos de alunos facilitados por tutores (RIBEIRO, 2008).

Conforme Berbel (1998), a ABP é uma sequência de problemas a serem estudados. Ao término de um, inicia-se o estudo do outro. O conhecimento adquirido em cada tema é avaliado ao final de cada módulo, com base nos objetivos e nos conhecimentos científicos. A opção pela Metodologia de ABP propicia o desenvolvimento de atividades educativas que envolvem participação individual, discussões coletivas, críticas e reflexivas. Essa metodologia compreende o ensino com uma visão complexa que proporciona aos alunos a convivência com a diversidade de opiniões, convertendo as atividades metodológicas em situações ricas e significativas para a produção do conhecimento e a aprendizagem para a vida. Propicia o acesso a maneiras diferenciadas de aprender e, especialmente, de aprender a aprender (VEIGA et. al., 2006).

Muitas empresas estão avançando em direção a uma dinâmica de aprendizagem contínua. A capacidade estratégica de gerar novos conhecimentos e coisas inéditas, de ter uma visão sistêmica e abrangente do todo, de ser competente e introduzir mudanças é decisiva para a manutenção das empresas na nova configuração do mercado. Torna-se crucial para elas, em particular aquelas situadas em ambientes altamente competitivos, a identificação e a sistematização dos processos de aprendizagem presentes nos sistemas de gestão e de trabalho, a fim de traduzi-los em novas competências, empregados e para a organização (DAVEL e MELO, 2005).

Para Reichel (2008) a criação de uma cultura de aprendizagem nas organizações é fundamental para dar respostas a um ambiente exigente, complexo e dinâmico. A existência dessa cultura depende dos vínculos estabelecidos entre as pessoas e a organização. O processo de aprendizagem na organização ocorre fornecendo condições concretas para que as pessoas aprendam a identificar sua própria realidade auxiliando-as a compreender o contexto em que vivem e interagir com ele.

De acordo com Neves (2006), o processo de aprendizagem perpassa por um procedimento que compreende o seguinte ciclo: inicia com o compartilhamento do conhecimento individual. Em seguida, a aprendizagem torna-se um processo social, partilhado pelas pessoas do grupo, gerando aprendizagem não só individual como também grupal. Depois da compreensão e da busca da solução para o problema compartilhada pelo grupo, discutem-se novamente os resultados com outros membros da empresa, motivando a proposição final para a solução do problema em forma de regras e procedimentos, o que cria condições favoráveis para aprendizagem organizacional.

3 Método de pesquisa

Este estudo teve como estratégia de pesquisa a Pesquisa-Ação por se caracterizar um estudo em que há a participação de todos os evolvidos e o comprometimento de mudança e melhorias. Yin (2001) descreve que a primeira e mais importante condição para diferenciar as várias estratégias de pesquisa é identificar nela o tipo de questão que está sendo apresentada. Definir as questões da pesquisa é provavelmente o passo mais importante a ser considerado em um estudo de pesquisa. A pesquisa-ação é um tipo de pesquisa social com base empírica que é concebida e realizada em estreita associação com uma ação ou uma resolução de um problema coletivo e no qual os pesquisadores e os participantes representativos da situação ou do problema estão envolvidos de modo cooperativo ou participativo (Thiollent, 1986).

A pesquisa teve início com quatro MPEs atuantes em diferentes setores, todas localizadas na cidade de Marabá, estado do Pará. A empresa um, atua no comércio varejista com a venda de lubrificantes para carros, está no mercado há 10 anos, possui um corpo de colaboradores com quatros funcionários. A segunda MPE participante, atua no mercado imobiliário há dez anos, possui um quadro de funcionários com cinco pessoas e atende uma boa parcela do mercado deste ramo na cidade. As duas últimas operam no ramo alimentício, uma vende produtos produzidos a partir dos frutos amazônicos e atua no mercado há dois com serviços de consultoria e possui dois funcionários e a outra comercializa bolos e doces com sabores diversos, está no mercado há oito meses e possui um quadro de funcionários com quatro colaboradores. Vale ressaltar, que nesta pesquisa foram considerados nos resultados somente das duas primeiras MPEs citadas, pois as demais não permaneceram até as reuniões finais.

Para a identificação e seleção dos problemas foi realizada uma reunião, onde teve a participação dos empresários das quatro empresas, do coordenador do grupo, facilitador e redator. Como a linha de estudo foi trabalhar a partir de problemas reais, os gestores pontuaram os problemas que enfrentam diariamente e que caracterizavam como mais frequentes. No decorrer da reunião os participantes foram orientados a listarem os devidos problemas em uma tabela, de acordo com a classificação do tipo de problema a ser analisado segundo os ciclos (planejamento, marketing, projetos, produção, custos), pautando quais os problemas mais urgentes e de interesse de cada um. A identificação de competência foi realizada por meio de uma entrevista efetuada com uso de um questionário, abordando as competências gerenciais que um gestor deve ter para desempenhar bem a sua função. Este questionário contou com nove aspectos sendo eles, a capacidade de condução de reuniões, o gerenciamento de conflitos, a liderança de grupo, a resolução de problemas, a tomada de decisão consensual, o trabalho em equipe, a tomada de decisão, a análise crítica e a comunicação.

Nesta etapa o coordenador do grupo, facilitador e relator visitaram cada empresa para a realização da entrevista. Foram entrevistados os gestores e mais dois funcionários, onde os gestores fizeram uma auto avaliação e os funcionários a avaliação das competências de seus gestores de acordo com os temas acima listados, para que assim os pesquisadores pudessem identificar a perspectiva dos gestores em relação as suas competências gerenciais e como os seus colaboradores os analisam. A implantação da ABP decorreu-se por meio da escolha de um problema que se encontrava em um dos temas tendo o início de um ciclo, em que trabalhou-se a problematização onde foram abordados uma análise da situação, definição do problema, assim como conjeturas para solução do problema por meio da troca de experiência e busca de informações. Após realizou-se a ação reflexão que consistiu em discutir a possível solução encontrada através dos resultados observados e dos questionamentos, assim como também a verificação se a solução seria adequada ou não, onde se esta não fosse retornaria para a problematização mas se caso fosse caracterizada como adequado se teria a continuidade para o planejamento da apresentação da solução.

Após seis meses de uso da ABP nas MPEs, foi possível realizar a coleta de dados. Estes foram analisados sob o ponto de vista do embasamento teórico realizado no início da pesquisa. O primeiro passo para a análise de dados foi a tabulação das informações sobre as competências organizacionais obtidas através da aplicação de um questionário, tratadas com o auxílio do *Microsoft Excel* 2013. Com este questionário foi possível identificar as autos avaliações dos gestores e a avaliação dos colaboradores em relação as competências dos gestores.

Além dessas informações foram realizadas a leitura das transcrições das reuniões e as entrevistas realizadas com os gestores, estes servem como fontes de evidência para a pesquisa.

4 Resultados

Nesta primeira etapa os gestores identificaram quais os problemas que ocorrem em cada uma das empresas estudadas, organizando-os em uma lista e classificando de acordo os temas: planejamento, produção, marketing, recursos humanos e projetos, trabalhados de acordo com urgência de cada tema, conforme Quadro 1, tendo como início o tema planejamento e o término com projetos. Denota-se que apesar de trabalharmos em uma determinada sequência é possível notar que praticamente todos os temas possuem a mesma quantidade de problemas, observa-se a necessidade de apoio para a resolução de problemas nas MPEs.

Após a identificação dos problemas realizou-se a aplicação do questionário de identificação de competências, com os gestores e seus funcionários, que teve como objetivo realizar o mapeamento das competências gerenciais dos gestores das empresas estudadas, permitindo o levantamento de informações referentes tanto a aspectos pessoais quanto a habilidades no trabalho, segundo 9 competências: condução de reuniões, gerenciamento de conflito, liderança de grupo, resolver problemas, tomada de decisão consensual, trabalho em equipe, tomada de decisão, análise crítica e comunicação. A partir dos resultados obtidos construiu-se o Gráfico 1, evidenciado abaixo, que permite visualizar a visão dos gestores (eu) sobre suas competências e como os colaboradores os analisam, verifica-se que as opiniões entre os gestores e os colaboradores possuem divergências, nota-se que os colaboradores possuem uma visão mais crítica em relação as competências dos gestores.

Mapeamento dos problemas- ABP			
	1- Planejamento		**2- Produção**
1	Ações com funcionários	1	Padronizações
2	Planejamento de fornecedores	2	Documentação
3	Aquisição de novos imóveis	3	Pós venda
4	Acompanhamento de despesas	4	Cobrança
5	Gerenciamento de tempo	5	Mão de obra especializada
6	Centralização de atividades	6	Compra de materiais
7	Planejamento de custos da consultoria	7	Melhorias para o empreendimento
8	Pesquisa de preço	8	Atendimento ao cliente
			4- Recursos humanos
		1	Alta rotatividade de funcionários
		2	Benefícios
		3	Reuniões
	3-Marketing	4	Treinamento
1	Conhecimento do mercado sobre o empreendimento	5	Advertências
2	Promoções	6	Padronização de cargos e funções dos funcionários
3	Brindes	7	Técnica de recrutamento e seleção
4	Propagandas	8	Programa de reconhecimento através da produtividade
5	Estética da empresa		**5- Projetos**
6	Obtenção de informações	1	Avaliar a necessidade de manutenção
7	Atrair mais clientes	2	Expanção da empresa
8	Fidelizar os existentes	3	Manter a pesquisa diária de funcionários
9	Difundir a marca nas regiões de atuação	4	Obtenção de recursos fins

Quadro 1 – Problemas identificados. Fonte: Autores, 2016.

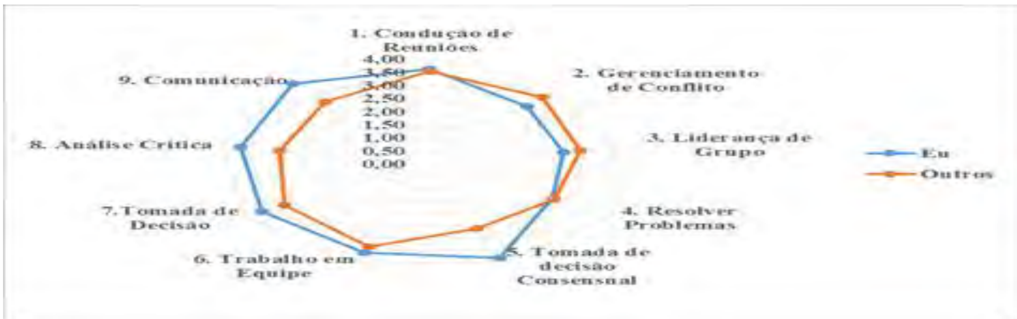

Gráfico 1 – Avaliação geral das competências gerenciais. Fonte: Autores, 2016.

Dentre as competências analisadas as que mais divergem são a tomada de decisão consensual, análise crítica e comunicação. Percebe-se que perante a perspectiva dos colaboradores, os gestores possuem limitações em suas habilidades gerenciais. Com o estudo exploratório notou-se que os gestores possuem um grande interesse em melhorar suas competências técnicas e no gerenciamento de pessoas, conseguem enxergar a sua importância, assim como a aquisição de aprendizado e o compartilhamento dos conhecimentos adquiridos em suas empresas. Os Gráficos 2 e 3 apresentam os resultados por gestor participante, realizando um comprativo entre o antes e o depois dos seis meses de uso da ABP.

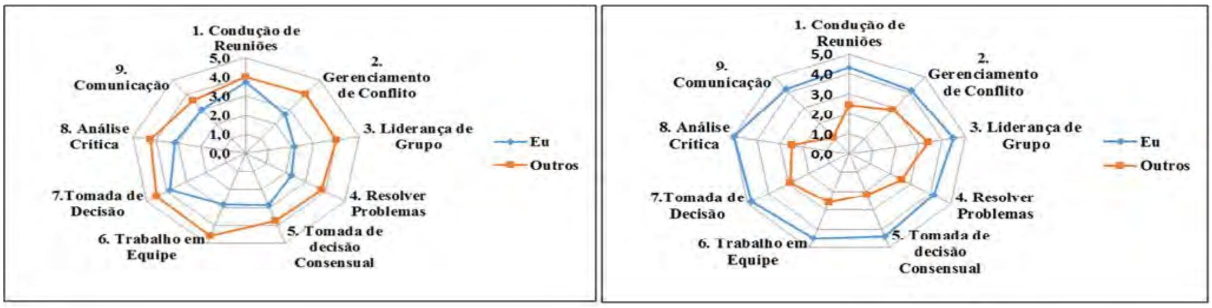

Gráfico 2 – Resultados antes e depois do Gestor 1. Fonte: Autores, 2016.

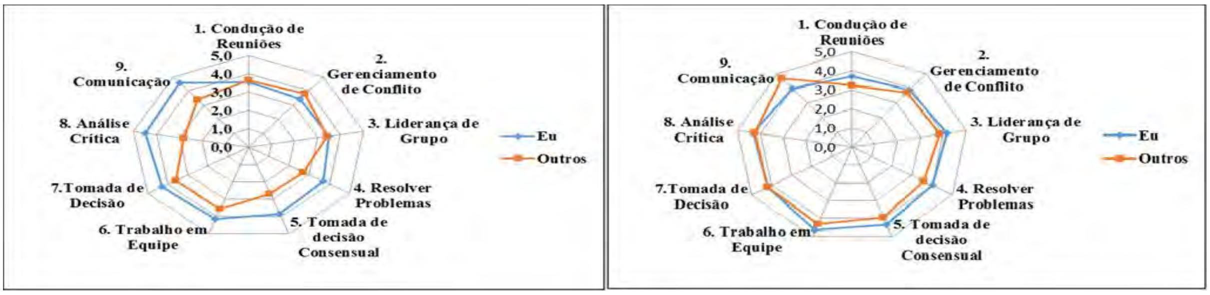

Gráfico 3 – Resultados antes e depois do Gestor 2. Fonte: Autores, 2016.

É importante ressaltar que o fato das suas competências não terem sido desenvolvidas e apresentarem resultado inferior após ao estudo realizado através da ABP, mostra um comando centralizador e avaliador sob uma única visão e ausência de definições que consigam orientar claramente as decisões dos seus subordinados. Em que não mantém um clima motivador e não busca a adaptação e implantação de inovações tendo a necessidade de um maior preparo e capacitação, para assim realizar mudanças e ter como premissa que a melhoria contínua faz com que empresa se reposicione e cresça diante ao ambiente interno, juntamente com seus colaboradores e apresente ao mercado um melhor desempenho.

É evidente que as competências que foram desenvolvidas estão relacionadas com o fato de o gestor ter conseguido motivar seus funcionários e assim fazer com que se interessassem em estar aprimorando suas habilidades e conhecimentos, notando-se que a comunicação dentro da organização se tornou mais eficiente, ocorrendo um feedback, onde o gestor conseguiu transmitir o seu aprendizado e proporcionou que seus colaboradores gerassem um aprendizado individual, obtendo a compreensão por parte dos mesmos, gerando o desenvolvimento de seus colaboradores.

Ressalta-se o desenvolvimento em resolver problemas, em o gestor estar capacitado e conseguir delimitar os problemas que sua empresa enfrenta e assim propor resoluções e fazer com que seus colaborares juntamente com empresa consigam atingir os objetivos estabelecidos e melhorar o desempenho da organização diante ao ambiente interno e frente aos concorrentes.

5 Conclusões

Os gestores demonstraram um nível de aprendizado satisfatório em relação aos temas abordados, assim adquirindo uma visão melhor sobre seus colaboradores, conseguindo enxergar que o problema não está somente no funcionário e que pode estar em como eles se comportam em determinadas situações, que podem levar a desmotivação dos mesmos, desenvolvendo suas competências de liderança em que conseguem motivar, capacitar e transmitir informações e conhecimento de forma clara e ordenada dentro da organização. Aos gestores que aplicaram o plano de ação juntamente com seus colaboradores referente a melhoria no atendimento, por meio de relatos dos mesmos, demonstraram que as MPEs obtiveram o aprendizado individual tantos dos gestores quanto em seus colaboradores, assim como também a aprendizagem coletiva e consequentemente organizacional, proporcionando melhorias no atendimento, nas relações interpessoais entre os gestores e funcionários, no desempenho durante expediente e claro maiores resultados para empresa no âmbito externo e interno.

Com aplicação do plano de ação foi possível que compartilhassem seus conhecimentos adquiridos e gerenciar esse conhecimento disponível de forma eficaz e contínua, fazendo com que os colaboradores adquirissem e desenvolvessem a sua própria aprendizagem individual onde o gestor como líder proporcionou a motivação e assim gerar a iniciativa do trabalhador em aprender, desempenhar suas funções eficientemente e seu crescimento pessoal e profissional.

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Variation of the motivation provided by the PBL according to the number of expositions of the students. Case Study with students from different classes of an Engineering College.

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Abstract

Problem-Based Learning (PBL) has been proposed as a mean to reduce demotivation and evasion of students from Engineering courses in Brazil and around the world. It can be applied at different times throughout the course depending on availability and interest of teachers and institutions. An experiment was carried out at a Brazilian College, named FARO - Faculdade de Roseira, simultaneously applying a PBL activity to two classes: one of "Science and Technology of Materials" - from the third period of the course, which discovered the methodology in this event, and another one of " Metallurgy and Mechanical Properties "- from the seventh period of the course, whose students had already passed at least five activities in the model (including one when they were in the Materials Science class two years before). This article tries to understand by means of a Likert evaluation questionnaire the individual perception of students after the application of this methodology in a class in order to qualitatively measure their motivation in the end of the activity. A comparison in terms of motivation is made between the students exposed for the first time to the methodology with that of students already, to a certain extent, habituated, or at least more exposed, to activities in this format, to understand whether motivation is stable, decreases or increases with exhibition, in order to allow the definition of the best pedagogical strategy of application of the same throughout the disciplines and Engineering courses..

Keywords: Problem Based Learning; Active Learning; Engineering Education; Active Learning & Teaching Methodologies.

Variação da motivação proporcionada pelo PBL em função do número de exposições dos alunos. Estudo de caso com alunos de diferentes turmas em uma Faculdade de Engenharia.

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Resumo

A Aprendizagem Baseada em Problemas (PBL, na sigla em inglês) tem sido proposta como um meio para reduzir a desmotivação e evasão de alunos nos cursos de Engenharia no Brasil e ao redor do mundo. Ela pode ser aplicada em diferentes momentos ao longo do curso em função da disponibilidade e interesse dos professores e das instituições. Um experimento foi realizado na FARO – Faculdade de Roseira, São Paulo, aplicando simultaneamente uma atividade PBL a duas turmas: uma de "Ciência e Tecnologia dos Materiais" - do terceiro período do curso, que descobria a metodologia nesse evento, e outra de "Ensaios e Metalurgia Mecânica" - do sétimo período do curso, cujos alunos já tinham passado por no mínimo cinco atividades no modelo (inclusive uma quando eram da turma de Ciência dos Materiais, há dois anos). O presente artigo busca compreender por meio de um questionário de avaliação Likert a percepção pessoal dos estudantes após a aplicação dessa metodologia em uma aula a fim de medir qualitativamente a motivação dos mesmos ao fim da atividade. Através da comparação da percepção de motivação de alunos submetidos pela primeira vez à metodologia com a de alunos já, de certa forma, habituados, ou ao menos mais expostos, a atividades nesse formato, entender se a motivação é estável, diminui ou aumenta com a exposição. O intuito é permitir a definição da melhor estratégia pedagógica de aplicação da mesma ao longo das disciplinas e dos cursos de Engenharia.

Keywords: Aprendizado Baseado em Problemas; Ensino em Engenharia; Aprendizado Ativo; Metodologias Ativas de Ensino.

1 Introdução

O engenheiro é o profissional cuja função por excelência é a tradução de novas ideias e tendências do mercado em novos produtos e processos, constituindo-se, portanto, em ator privilegiado e fundamental de um ecossistema inovador. Sendo assim, a oferta de engenheiros de qualidade e a existência de demanda por esses profissionais são pilares fundamentais de uma trajetória de desenvolvimento econômico baseada na inovação (Salerno, Toledo, Gomes & Melo Lins, 2013).

No entanto, os cursos tradicionais de engenharia, na maioria das escolas de engenharia, são estruturados de uma maneira em que os conhecimentos estão compartimentados em disciplinas estanques, não dando conta das demandas em razão da multidisciplinaridade da formação exigida do engenheiro e não atendem as expectativas do mercado de trabalho, da formação profissional, das empresas e da sociedade (Manrique, Dirani & Campos, 2010).

A partir da compreensão de que o estudante de engenharia, ao longo de sua trajetória escolar no curso, apresenta uma evolução não só em termos de ampliação de seus conhecimentos e de construção de competências técnicas, mas também de atitudes que o levam a desenvolver, paulatinamente, a sua autonomia, percebe-se que as estratégias pedagógicas utilizadas no ensino devem estar ajustadas às diferentes fases dessa evolução como pré-condição para o sucesso dessas estratégias. Apesar de, na perspectiva das atitudes e competências intelectuais, as condições iniciais serem favoráveis para o sucesso escolar desses estudantes, muitos deles evadem nas primeiras etapas dos Cursos. O baixo percentual de formandos (em muitas Instituições em torno de 50% dos ingressantes), deve-se, em parte, a essa evasão inicial (Loder, 2016).

Nos Estados Unidos, menos de 40% dos estudantes que ingressam na faculdade com intenção de obter um diploma na área de "Ciências, Tecnologia, Engenharia e Matemática" (STEM, na sigla em inglês) gradua-se realmente em um desses cursos. Grande parte dos alunos que abandonam a área STEM migram para áreas fora das exatas. Uma análise desse êxodo nas disciplinas de exatas mostra que muitos dos estudantes que abandonam os cursos STEM apresentam bons resultados, mas descrevem as metodologias de ensino e o ambiente nas matérias introdutórias dos cursos como ineficientes e desmotivadores (PCAST, 2012).

Um estudo patrocinado pelo Conselho Australiano de Ensino e Aprendizagem buscou entender e buscar soluções para a evasão nas escolas de engenharia daquele país. Uma das instituições avaliadas foi o curso de Engenharia Química da Universidade de Queensland. Nesse trabalho, segundo Crosthwaite & Aubrey (2011), as três principais causas que levaram os alunos a deixar a engenharia, a partir de uma avaliação que incluiu cursos de oito universidades australianas foram:

- Falta de compromisso e de entusiasmo pela engenharia;
- Progresso acadêmico deficiente e
- Programa do curso que não atende às expectativas dos alunos, que podem ser potencializadas por questões pessoais, do currículo ou de calendário.

Pode-se depreender desta constatação que criar nas universidades condições satisfatórias, desafiantes e estimulantes no conteúdo e estruturação dos cursos de engenharia pode ser um fator determinante para a reversão da perda de alunos (Cavalcante & Embiruçu, 2013).

O PBL, ou Aprendizado Baseado em Problemas (Hung, Jonassen & Liu, 2008), acontece quando os estudantes têm a oportunidade de unir teoria e prática e desenvolver habilidades técnicas e de gestão. O Aprendizado Baseado em Problemas é uma pedagogia que prepara os estudantes para o mundo real por meio de atividades que propiciam o pensamento crítico, habilidades de negociação, responsabilidade e construção do consenso durante o processo de aprendizado em si (Correa, Mantovani & Veraldo Júnior, 2015).

Experiências positivas mostram que a adoção do Aprendizado Baseado em Problemas (PBL) nos cursos de Engenharia tem estimulado e promovido a permanência dos alunos nos cursos até o final da graduação. Neste contexto, esta metodologia pode constituir uma interessante alternativa pedagógica para elevar a taxa de formação e a qualificação profissional dos engenheiros no país, além de tornar os cursos de Engenharia opções mais estimulantes e atraentes (Cavalcante & Embiruçu, 2013).

Por meio da realização de uma atividade PBL de maneira interdisciplinar com estudantes de diferentes cursos de Engenharia da FARO – Faculdade de Roseira, com diferentes níveis de exposição pregressa ao modelo , o presente artigo tem como objetivo, além de relacionar a motivação dos alunos com a aplicação do PBL, comparar, por meio de um questionário Likert aplicado a esses estudantes logo após a exposição ao evento, se sua motivação aumenta, diminui ou se mantém estável em função do aumento do número de exposições dos alunos à essas metodologias de aprendizado, permitindo melhor definição da estratégia de aplicação dessas metodologias ao longo das disciplinas e, de maneira mais global, ao longo do próprio curso de Engenharia.

2 Revisão Bibliográfica

As soluções para os problemas de abastecimento de alimentos e energia, com o crescimento estimado da população mundial no século XXI, passarão necessariamente pelos profissionais de Engenharia. Neste contexto, o engenheiro precisa estar preparado adequadamente para trabalhar com novas tecnologias, produtos e processos, num ambiente multidisciplinar onde não se pode prescindir das suas responsabilidades sociais, éticas e ambientais (Campos, Lima, Alves, Mesquita, Moreira & Campos, 2013).

Notam-se tentativas para que sejam adotadas, como estratégia de ensino, práticas pedagógicas inovadoras – também chamadas de metodologias ativas. Isso requer dos profissionais constantes reflexões sobre suas ações e planejamento baseado na realidade, sendo necessário incentivar e adequar as práticas educativas (Sobral & Campos, 2012).

Muitas estratégias utilizadas como inovadoras ou métodos ativos de ensino, se baseiam teoricamente na metodologia de problematização de Paulo Freire (Freire, 1998), mas que nem sempre são de fato transformadoras, por serem aplicadas de forma tradicional. Portanto, é preciso fundamentar a prática educativa, onde o docente elabore de forma crítica e avalie seus recursos para saber se são eficazes de fato (Souza, 2017).

Nesse contexto, uma dessas Metodologias Ativas, o Aprendizado Baseado em Problemas (PBL) pode ser definido como um método de ensino-aprendizagem que propicia ao aluno adquirir conhecimento no contexto de problemas. Esse método de aprendizagem ativa de ensino tem sua fundamentação no pressuposto de que a aprendizagem não é um simples processo de recepção de informações, mas de construção de significados (Araújo, Araújo & Brito, 2016).

2.1 Metodologias ativas e o ensino de Engenharia

O ensino de Engenharia deve ter como objetivo propiciar uma aprendizagem significativa, contextualizada e orientada para o uso das tecnologias contemporâneas. Deve também favorecer o uso dos recursos da inteligência, gerando habilidades em resolver problemas e conduzir projetos nos diversos segmentos do setor produtivo. Além do preparo requerido para a construção de competências técnicas, é indispensável que o profissional de Engenharia seja capaz de exercer valores e condições de formação humana, considerados essenciais no mundo do trabalho contemporâneo. Dentre esses valores, destacam-se: conduta ética, capacidade de iniciativa, criatividade, atitude empreendedora, flexibilidade, autocontrole, comunicação, expressão oral e escrita, dentre outros (Barbosa & Moura, 2014).

O atual modelo de formação de engenheiros oferece ao aluno uma representação "bidimensional", narrativa de uma realidade que é tridimensional e complexa. Desvinculada dessa realidade, a teoria acaba perdendo o papel de importante ferramenta para sua compreensão (Lourenço Jr & Veraldo Jr, 2015).

A Confederação Nacional da Indústria (CNI), o Instituto Evaldo Lodi (IEL) e o Serviço Nacional de Aprendizagem Industrial (SENAI) publicaram dois manifestos – um em 2006 chamado Inova Engenharia e outro em 2010 denominado Engenharia para o Desenvolvimento – apontando a necessidade de modernizar o ensino de engenharia e dar relevo às atividades práticas. Essa necessidade foi verificada também por outros países como os EUA, ao criar o *Olin College* em 1997 e o projeto CDIO (*Conceive, Design, Implement, Operate*) em 2000, este último liderado pelo *Massachusetts Institute of Technology* (MIT), a mais respeitada escola de engenharia do mundo. Em 2011 foi criado o iLab: laboratório de inovação de Harvard (Gardenal, 2014).

Independentemente da estratégia usada para promover a aprendizagem ativa, é essencial que o aluno faça uso de suas funções mentais de pensar, raciocinar, observar, refletir, entender, combinar, dentre outras que, em conjunto, formam a inteligência. Ou seja, a diferença fundamental que caracteriza um ambiente de aprendizagem ativa é a atitude ativa da inteligência, em contraposição à atitude passiva geralmente associada aos métodos tradicionais de ensino (Barbosa & Moura, 2014).

2.2 PBL – Aprendizagem Baseada em Problemas

A sistematização da metodologia de Aprendizagem Baseada em Problemas (PBL, na sigla em inglês) surgiu na década de 60 no Canadá, onde foi inicialmente aplicada nas escolas de medicina. Apesar da aplicação inicial na área médica, o PBL tem sido utilizado em várias outras áreas do conhecimento, como administração, arquitetura, ciências da computação, ciências sociais, economia, engenharias e matemática (Araújo, 2011).

O PBL é essencialmente um método de ensino-aprendizagem que utiliza problemas da vida real (reais ou simulados) para iniciar, enfocar e motivar a aprendizagem de teorias, habilidades e atitudes. O PBL, como outros métodos de aprendizagem ativa, está pautado no pressuposto de que o conhecimento é construído em vez de simplesmente memorizado e acumulado (Silva, Silva, Martins & Neves, 2016).

Enquanto nos métodos convencionais o objetivo é a transmissão do conhecimento centrada no professor, em conteúdos disciplinares, no PBL o aprendizado passa a ser centrado no aluno, que deixa de ser um receptor passivo da informação para ser agente ativo do seu aprendizado. Nesse contexto, o professor atua como orientador ou facilitador nos grupos de trabalho ou estudo, nos quais a interação entre professor e aluno é muito mais intensa do que em aulas puramente expositivas (Ortiz, 2016).

A Aprendizagem Baseada em Problemas procura transformar um problema como base de motivação para o aprendizado, dando ênfase à construção do conhecimento em ambiente colaborativo. A ideia não é ter sempre o problema resolvido no final, mas sim enfatizar o processo seguido pelo grupo na busca de uma solução, valorizando a aprendizagem autônoma e cooperativa (Barbosa & Moura, 2014).

Assim, a adoção pelas instituições educativas da Aprendizagem Baseada em Problemas articulada com novas e diversas Tecnologias de Informação e Comunicação e a preocupação com a ética pessoal e profissional configuram-se como ferramentas poderosas para formar as novas gerações nas condições exigidas por sociedades que buscam estruturar-se em torno de conhecimentos sólidos e profundos, visando a inovação, a transformação da realidade e a construção da justiça social (Araújo, 2011).

3 Metodologia

Este capítulo foi dividido em duas grandes linhas: a primeira, com a descrição da aula em questão e seu modo de execução e a segunda, onde se indica a forma escolhida para o levantamento de dados, com o intuito de comparar a motivação dos alunos propiciada pelo PBL.

3.1 Modelo de Aprendizado Ativo aplicado às turmas de 3º e 7º períodos de Engenharia na FARO

As disciplinas "Ensaios e Metalurgia Mecânica" do 7º período de Engenharia Mecânica e "Ciência e tecnologia dos materiais" do 3º período das Engenharias (Mecânica, Civil, Química, Elétrica e Ambiental) são complementares, segundo o Projeto Pedagógico e Curso (PPC) da FARO (FARO, 2015). Desta forma, idealizou-se a realização do experimento PBL multidisciplinar onde os alunos das duas turmas foram incentivados a realizar cooperação mútua e intercambiar conhecimentos com a finalidade de solucionar os problemas apresentados.

Esse experimento consistiu de uma aula com duração de 3 horas, em formato PBL, aplicada simultaneamente para as duas turmas no 1º semestre de 2017. A união das duas turmas permitiu aos alunos do 7° período correlacionar os resultados dos ensaios às propriedades mecânicas e estruturas dos materiais. Já os alunos de Ciência e Tecnologia dos Materiais puderam antecipar a aplicação prática (ensaios) dos conceitos que vem sendo apresentados em sua disciplina.

Participaram da aula 34 alunos, sendo 10 matriculados na disciplina "Ensaios e Metalurgia Mecânica" e 24 inscritos em "Ciência e Tecnologia dos Materiais". Estiveram presentes também os professores de ambas as disciplinas. Os alunos foram divididos em cinco grupos, com no máximo 7 alunos em cada. Havia uma regra para a construção dos grupos: Cada grupo devia contar com a presença de dois alunos da turma de Ensaios e Metalurgia Mecânica, de forma a assegurar a interdisciplinaridade durante o experimento.

O objetivo principal da aula foi que grupos constituídos de alunos das duas turmas pudessem resolver um problema simples e direto, que simulava um caso industrial real. Entretanto, para aumentar o foco e a motivação dos alunos a aula foi dividida em três momentos (Furtado & Laurito, 2016):

<u>Parte 1:</u> Realização de uma série de exercícios rápidos em que os grupos foram avaliados pelo tempo de resposta, criando assim uma competição que os deixasse focados, além de introduzir a noção de "time".

<u>Parte 2:</u> Aplicação do PBL propriamente dito, porém com uma adaptação: Como o problema exigia diversos conceitos diferentes, era sabido pelos professores que nenhum grupo chegaria à resposta no tempo disponibilizado para tal. Entretanto, a seguir, foi feita a mudança sequenciada de um membro de cada grupo passando por todos os outros. Assim, os conceitos foram compartilhados e, ao final do exercício, todos os grupos chegaram ao resultado desejado.

<u>Parte 3:</u> Debate para que os alunos se auto avaliassem, concluindo quais grupos entenderam melhor os conceitos em menor tempo, contribuindo de forma mais significativa para o resultado final. É a própria discussão e auto avaliação dos estudantes que gera a nota final de cada um deles na atividade.

3.2 Percepção dos alunos sobre o processo e a influência no aprendizado: Definição dos critérios e forma de avaliação

Todos os alunos participantes da aula foram informados sobre o projeto que descrevia todo o processo de pesquisa, o objetivo e a importância da veracidade da resposta de cada participante para a confiabilidade do resultado. Além disso, tomaram ciência de que os dados e resultados seriam transformados em base para artigo científico para publicação.

A avaliação dos resultados foi realizada em escala Likert, o que significa que os participantes responderam a um questionário especificando seu nível subjetivo de avaliação em uma escala simétrica para cada item. A faixa de resultado obtido indica a intensidade dos seus sentimentos para um dado item (Barua, 2013). Foram disponibilizadas para cada item cinco respostas possíveis: muito pior, pior, indiferente, melhor e muito melhor, relacionando a percepção dos alunos da aula em formato MAs (Metodologias Ativas, que – no caso – foi o PBL) às aulas no método tradicional.

Desta forma, para permitir a avaliação em escala Likert, o instrumento de avaliação foi composto por um questionário por aluno participante da aula, composto por sete itens, cada item com cinco possibilidades de resposta, conforme ilustrado a seguir (Figura 1).

Considerando a aula de hoje, em formato PBL, e comparando-a às aulas em formato tradicional, favor avaliar as questões abaixo, assinalando uma das opções para cada uma das situações:

Curso: ______________________ Nome (opcional): ______________________

	Muito pior	Pior	Indiferente	Melhor	Muito melhor
Como você compara experiência pessoal nessa aula, envolvendo MAs, em relação à tradicional?					
Em relação ao estímulo à criatividade, como você percebeu essa aula em MAs em relação ao modelo tradicional?					
Comparando ao modelo tradicional, como avalia o estímulo ao pensamento crítico facilitando a aprendizagem?					
Como você avalia a integração interdisciplinar que esse tipo de aula proporciona em relação ao modelo tradicional?					
Na aula de hoje, em relação ao modelo tradicional, como a sua habilidade de comunicação pode ser explorada?					
Classifique como foi a colaboração do seu time durante a atividade?					
Ao final dessa aula, e comparando a uma aula no modelo tradicional, como você avalia a sua motivação?					

Figura 37. Questionário em modelo Likert utilizado para avaliação da percepção dos alunos em relação ao PBL

A aplicação deste instrumento (inquérito por questionário) foi realizada ao final da aula, momento em que o projeto já havia terminado. Esperava-se, dessa forma, que os alunos pudessem refletir e discutir abertamente sobre o que ocorreu bem e o que poderia ser melhorado.

4 Resultados e Análises

Os questionários foram respondidos por todos os alunos, sem que houvesse abstenções. Desta forma, obteve-se um total de 34 respostas que foram organizadas de duas diferentes maneiras nesse estudo.

Os resultados foram tabulados inicialmente considerando todos os 34 alunos, indiferente da disciplina matriculada, em um único espaço amostral. As informações obtidas (item 4.1) foram utilizadas para comparar o impacto motivacional do PBL em relação às metodologias tradicionais de ensino.

Em seguida, no item 4.2, os dados foram tratados de maneira diferente. Tabulou-se separadamente as respostas dos alunos de cada disciplina. Foram avaliadas as respostas quanto ao índice motivacional das turmas relacionadas ao Aprendizado Baseado em Problemas comparando os discentes de Ciência e Tecnologia dos Materiais, que estavam participando pela primeira vez em uma aula neste formato com os alunos de Ensaios e Metalurgia Mecânica, que estavam na sua quinta atividade neste mesmo modelo

4.1 Análises da percepção dos alunos, considerados como um espaço amostral único

As respostas dos questionários de todos os alunos independente da turma a que pertenciam foram tabuladas e os resultados para cada uma das perguntas podem ser vistos a seguir (Figura 2).

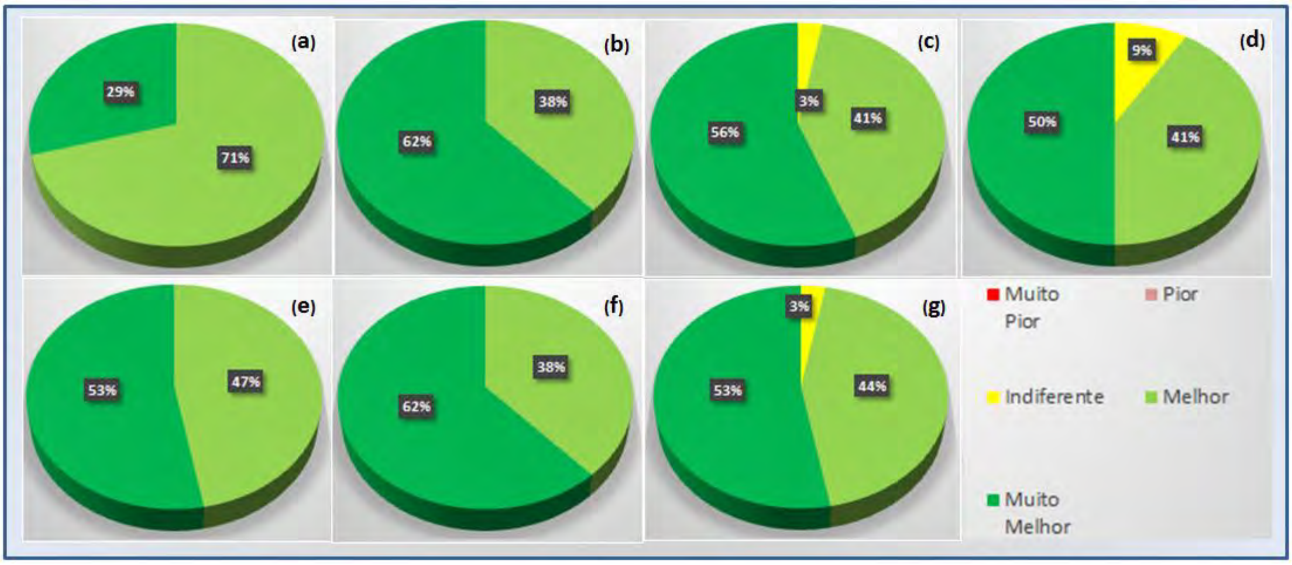


Figura 2. Resultados da pesquisa Likert considerando a avaliação dos alunos, independente da disciplina que cursam. Respostas indicam a percepção dos alunos em relação a (a) experiência pessoal, (b) estímulo à criatividade, (c) estímulo ao pensamento crítico, (d) integração interdisciplinar, (e) habilidade de comunicação, (f) trabalho em equipe e (g) motivação.

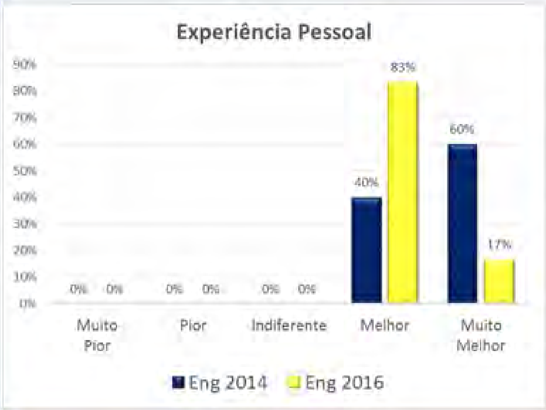
Observou-se um resultado bastante significativo em relação à percepção geral dos discentes com relação ao modelo de aula em formato PBL. A maioria dos alunos classificou o novo método de ensino como positivo em relação ao modelo tradicional, sendo que uma pequena quantidade dos discentes classificaram como indiferente os estímulos ao pensamento crítico, integração interdisciplinar e motivação. Mesmo nesses casos, o maior percentual atingido para indiferente foi de 9%.

Além disso, somente em um item, experiência pessoal, o percentual de melhor ultrapassou o de muito melhor. Em todos os outros, mais da metade dos alunos avaliaram o modelo como muito melhor quando comparado ao modelo tradicional. As melhores taxas foram alcançadas em relação aos itens estímulo a criatividade e trabalho em equipe, justificando a boa aceitação pelos discentes ao estilo de aula em formato PBL.

4.2 Comparação entre a percepção dos alunos do 3º e do 7º período, considerados separadamente

Nesse tópico, foram analisados os dados separadamente por turmas, a fim de identificar diferenças de percepção do método entre os alunos do 3° e 7° período. Sabendo que a turma do 7° período (Ensaios e Metalurgia Mecânica) teve maior número de exposições ao método do que a do 3° período (Ciência e Tecnologia dos Materiais), a comparação dos resultados por turma permite identificar variações de percepção por parte dos alunos em função do seu maior ou menor conhecimento e envolvimento com o PBL.

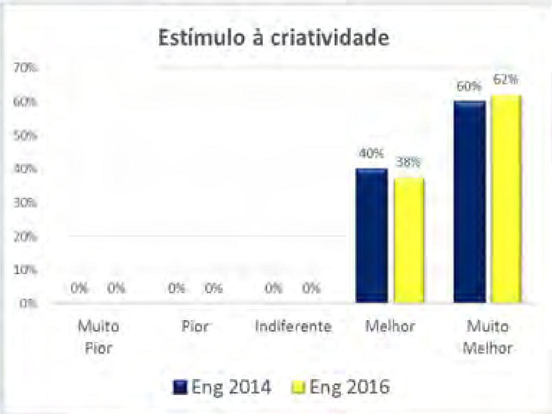
Nas Figuras de 3 a 9 verifica-se o resultado obtido por turma nos questionários, pergunta a pergunta.



Em relação à experiência pessoal com a aula, pode-se notar que entre os alunos de Ciência e Tecnologia dos Materiais (Eng 2016) que estão participando de uma atividade em PBL pela primeira vez, apenas um percentual baixo avalia a aula como sendo "muito melhor" que a tradicional. Quase 85% dentre eles reconhecem a experiência como "melhor".

Por outro lado, entre os alunos de Ensaios e Metalurgia Mecânica (Eng 2014) o percentual dos que consideram sua experiência como "muito melhor" ultrapassa a parcela daqueles que julgam apenas "melhor", chegando aos 60% .

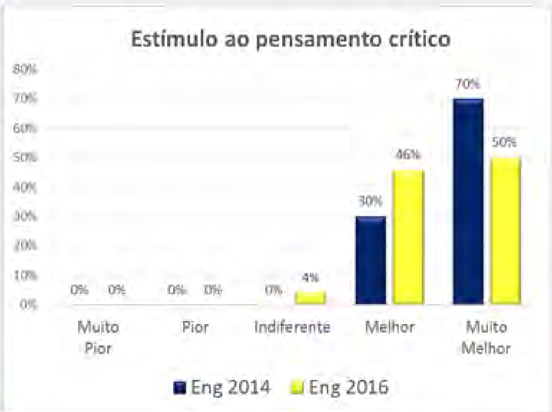
Figura 3. Resultados da pesquisa Likert, por turma, para a questão: "Como você compara experiência pessoal nessa aula, envolvendo MAs, em relação à tradicional? "



Ao responder à questão "Em relação ao estímulo à criatividade, como você percebeu essa aula em MAs em relação ao modelo tradicional?" nota-se que a maioria dos estudantes tanto da turma Eng 2014 (Ensaios e Metalurgia Mecânica) quanto da turma Eng 2016 (Ciência e Tecnologia dos Materiais) comportam-se de maneira similar:

- ❑ Todos consideram o modelo mais estimulante que o tradicional;
- ❑ A maior parte deles, em torno de 60%, julga o PBL "muito melhor" do que uma aula expositiva convencional

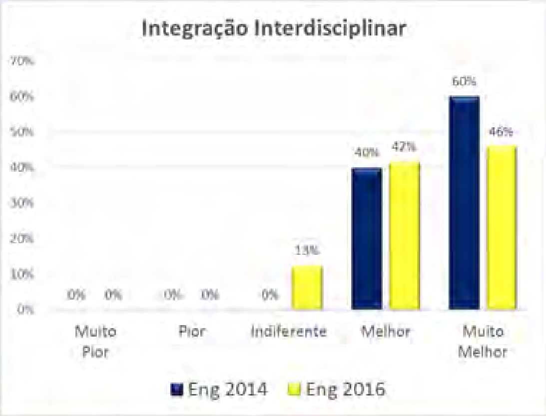
Figura 4. Resultados da pesquisa Likert, por turma, para a questão: "Em relação ao estímulo à criatividade, como você percebeu essa aula em MAs em relação ao modelo tradicional?"



Na avaliação do estímulo ao pensamento crítico, uma pequena parcela dos alunos da turma de Ciência e Tecnologia dos Materiais (Eng 2016), pouco menos de 5%, considerou o PBL indiferente em relação ao método tradicional de ensino. O restante da turma praticamente se dividiu entre considerar o PBL "melhor" e "muito melhor".

A turma de Ensaios e Metalurgia Mecânica apresentou uma avaliação bastante diferente: Todos os alunos consideraram a Aprendizagem Ativa como melhor, com um percentual de 70% para "muito melhor".

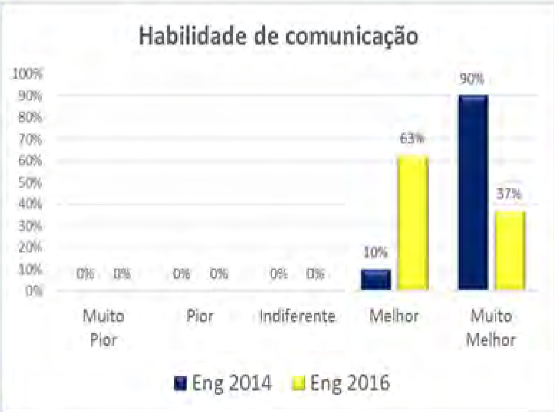
Figura 5. Resultados da pesquisa Likert, por turma, para a questão: "Comparando ao modelo tradicional, como avalia o estímulo ao pensamento crítico facilitando a aprendizagem?"



Integração interdisciplinar, esse foi o item onde houve maior avaliação como indiferente para o PBL. Esse resultado só ocorreu, entretanto, para a turma de Ciência e Tecnologia dos Materiais (Eng 2016), onde 13% avaliaram o método como indiferente. O restante da turma praticamente se dividiu entre considerar o PBL "melhor" e "muito melhor".

Na turma de Ensaios e Metalurgia Mecânica (Eng 2014) a avaliação foi parecida com a das outras questões: Todos os alunos consideraram a Aprendizagem Ativa como melhor, com um percentual de 60% para "muito melhor".

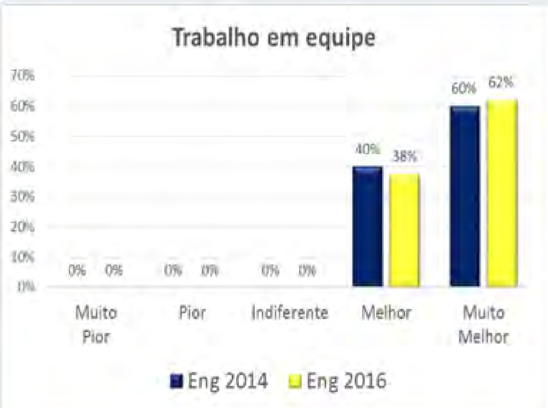
Figura 6. Resultados da pesquisa Likert, por turma, para a questão: "Como você avalia a integração interdisciplinar que esse tipo de aula proporciona em relação ao modelo tradicional?"



Ao avaliar a habilidade de comunicação, a percepção de melhora do PBL em relação ao método tradicional foi generalizada. Nenhum aluno avaliou o método como indiferente.

Por outro lado, esse foi o item em que houve maior divergência entre as turmas. A maioria dos alunos da turma de Ciência e Tecnologia dos Materiais (Eng 2016), 63%, avaliou o processo como "melhor" e apenas 37% como "muito melhor". Já na turma de Ensaios e Metalurgia Mecânica (Eng 2014) 90% dos alunos avaliaram o PBL como "muito melhor" que o modelo tradicional de aulas expositivas.

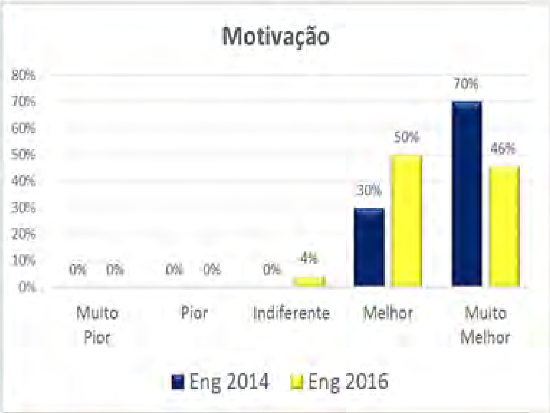
Figura 7. Resultados da pesquisa Likert, por turma, para a questão: "Na aula de hoje, em relação ao modelo tradicional, como a sua habilidade de comunicação pode ser explorada?"



Ao avaliar a colaboração do seu time durante a atividade percebe-se um comportamento similar dos alunos: a maioria dos estudantes tanto da turma Eng 2014 (Ensaios e Metalurgia Mecânica) quanto da turma Eng 2016 (Ciência e Tecnologia dos Materiais), sendo que:

- Todos consideram o modelo mais estimulante que o tradicional;
- A maior parte deles, em torno de 60%, julga o PBL "muito melhor" do que uma aula expositiva convencional

Figura 8. Resultados da pesquisa Likert, por turma, para a questão: "Classifique como foi a colaboração do seu time durante a atividade"



Fechando o questionário, ao fim da aula, em relação à motivação, uma pequena parcela dos alunos da turma de Ciência e Tecnologia dos Materiais (Eng 2016), pouco menos de 5%, considerou o PBL indiferente em relação ao método tradicional de ensino. O restante da turma praticamente se dividiu entre considerar o PBL “melhor” e “muito melhor”.

A turma de Ensaios e Metalurgia Mecânica (Eng 2014) apresentou uma avaliação bastante diferente: Todos os alunos consideraram a Aprendizagem Ativa como melhor, com um percentual de 70% para “muito melhor”.

Figura 9. Resultados da pesquisa Likert, por turma, para a questão: “Ao final dessa aula, e comparando a uma aula no modelo tradicional, como você avalia a sua motivação?”

5 Conclusões

Em relação à avaliação global do impacto na motivação, os resultados obtidos na Figura 2 mostraram que o PBL é considerado pelos alunos uma metodologia mais adequada para estimular a inovação, intercomunicação e o trabalho em conjunto. À exceção dos itens estímulo ao pensamento crítico, integração interdisciplinar e motivação, onde um reduzido percentual de alunos considerou o método como indiferente, em todos os outros a totalidade dos discentes o considerou melhor ou muito melhor do que o ensino tradicional com aulas expositivas.

Esse resultado demonstrou um grupo atípico, pois nesses experimentos é comum haver um pequeno percentual de alunos mais tímidos ou introspectivos que, em geral, sobretudo nos primeiros contatos, avaliam o método como pior que o ensino tradicional, como exposto em outros artigos e pesquisas sobre o assunto.

Desta forma, é possível concluir que, desde o primeiro contato até casos em que os alunos estão mais expostos ao PBL, o método é eficaz para aumentar a motivação e o interesse dos alunos pelo aprendizado.

Ao se avaliar a percepção dos alunos, separadamente por turmas, fez-se possível dividir as questões em alguns grupos em função da tendência dos resultados:

Grupo 1 – Itens que foram avaliados de maneira similar pelas diferentes turmas. Enquadraram-se nesse modelo o estímulo à criatividade (Figura 4) e o trabalho em equipe (Figura 8). Esse resultado indicou que os alunos, desde sua primeira experiência com o PBL, já têm uma percepção que se manterá ao longo do tempo. Isso pode estar ligado ao fato de essas duas características não estarem diretamente ligadas ao conhecimento pregresso o que nivelaria os alunos e não deixaria aqueles da turma mais no início do curso se sentindo de alguma forma em desvantagem aos que teriam mais conhecimento e experiência.

Grupo 2 – Itens em que a avaliação dos alunos melhora quando sua vivência com o PBL aumenta, através da repetição da metodologia. Nesse grupo se encontram os itens estímulo ao pensamento crítico (Figura 5), integração interdisciplinar (Figura 6) e motivação (Figura 9). Analisando os resultados desse grupo, nota-se um aumento em até 20 pontos percentuais da proporção de “Muito melhor” nos alunos da turma mais exposta ao PBL em relação aos da turma que é apresentada ao método pela primeira vez

Grupo 3 – Itens em que a avaliação dos alunos melhora significativamente ao aumentar a exposição ao método. Experiência pessoal (Figura 3) e habilidade de comunicação (Figura 7) apresentaram essa característica. Para esses dois itens o aumento do número de respostas “muito melhor” foi superior a 40 pontos percentuais. Nesses itens, a análise inversa aos do grupo 1 pode ser uma das causas da sensível melhora, ou seja, podem ser o impacto do primeiro contato e a situação de estarem em um período inferior que geram essa sensação menos positiva nos alunos que estão descobrindo o PBL.

Além dos três grupos distintos de resultados, outra característica também se revela muito clara nos resultados: Entre os alunos de Ciência e Tecnologia dos Materiais (que descobrem o PBL) há itens em que surge a avaliação indiferente e outros em que a sensação de "melhor" supera a de "muito melhor". Já entre os alunos que estão mais habituados ao modelo de aprendizado ativo (alunos de Ensaios e Metalurgia Mecânica), além de não aparecer nenhuma avaliação indiferente, em todos os itens a proporção de "muito melhor" supera a de "melhor".

Essas análises somadas permitem concluir que, além da Aprendizagem Baseada em Problemas gerar motivação aos estudantes, a repetição desse modelo aumentou o incentivo ao método. Sendo assim, é assertivo iniciar a aplicação do PBL logo no início de uma disciplina ou mesmo do curso, visto que mesmo os alunos principiantes motivam-se com a metodologia. Dessa maneira, os índices de evasão nos cursos das áreas de exatas poderiam ser reduzidos, sabendo que a desmotivação é citada como um dos motivos de desistência da formação.

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Reformulation of Energy Conversion Laboratory Experiments Using PBL

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Abstract

Brazil's educational system is facing great changes that will have significant impact upon the whole country. Universities alongside their innovating and encouraging role in researches in society also face continuous changes looking for the improvement of both the education and the educational approach. Learning is cooperation between teachers and students therefore it is necessary that both parts make an effort so that the student's graduation is enough to make them feel prepared for the job market. The purpose of this paper is promoting the use of updated educational approaches that encourage the active learning within the Electrical Engineering course at the University of Brasília.In order to promote the encouragement a course was taken as an example: The Energy Conversion Laboratory, one of the practical course from the 8th semester of Electrical Engineering program, which had its experiments guidelines modified to a Project Based Learning approach. A comparison is made with the prior experiments to show the benefits of active learning for students. The course comprehends rotating machines (synchronous, asynchronous and also DC machines, for instance) inside of a lab with electronic counters. Concluding, all updated experiments have a problem based in a real engineering application, where students are supposed to use their critical thinking and also uses their knowledge background in practice (with interdisciplinary topics). That brings together the future worker and the problems that are to be faced in the daily job market's working routine.

Keywords: Active Learning; Engineering Education; Project Approaches; Electrical Engineering; Project Based Learning; Electrical Machines; Energy Conversion.

Reformulação dos Roteiros Didáticos do Laboratório de Conversão de Energia Utilizando PBL

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Resumo

O sistema educacional brasileiro como um todo está passando por grandes transições que terão impacto direto sobre todo o país. As universidades, com seu papel inovador e incentivador de pesquisas dentro da sociedade, também passam por constantes mudanças em busca do aperfeiçoamento do ensino e abordagens pedagógicas. O aprendizado é uma via de mão dupla entre discente e docente, e é necessário um esforço de ambas as partes para que a formação do aluno seja genuína para sua inserção no mercado de trabalho. O objetivo do trabalho é fomentar o uso de abordagens educacionais atualizadas que incentivem o aprendizado ativo dentro do curso de Engenharia Elétrica da Universidade de Brasília. Com o intuito de promover o fomento, uma disciplina foi escolhida como exemplo. O Laboratório de Conversão de Energia, uma das matérias práticas do curso do oitavo semestre, que teve seus roteiros modificados para uma abordagem em PBL (Project Based Learning). É feito uma comparação com os experimentos anteriores para mostrar os benefícios do aprendizado ativo para o aluno. A disciplina aborda o tema de máquinas rotativas (como máquinas síncronas, assíncronas e de corrente contínua) dentro de um laboratório com bancadas de eletrotécnica. Assim, todos os ensaios atualizados têm um problema baseado em uma aplicação real de engenharia, em que os alunos devem exercer seu pensamento crítico para usar sua bagagem de conhecimento (com assuntos diversos e interdisciplinares) na prática. Isso aproxima o futuro profissional dos problemas que serão enfrentados no seu dia-a-dia no mercado de trabalho.

Palavras-chave: Aprendizado Ativo; Educação em Engenharia; Abordagens de Projetos; Engenharia Elétrica; Aprendizado Baseado em Projetos; Máquinas Elétricas; Conversão de Energia.

1 Introdução

1.1 Contextualização

A Universidade deve ser o principal incentivador de soluções criativas para problemas existentes na sociedade e, além disso, ser o celeiro de futuros grandes projetos. A Universidade de Brasília (UnB) nasceu em 1962 com a proposta de ser uma instituição com um espírito inovador. Os modelos propostos pelo antropólogo Darcy Ribeiro e pelo educador Anísio Teixeira tinham como base uma universidade livre onde o aluno não fosse dependente do professor e pudesse seguir segundo suas próprias experiências. O modelo era muito revolucionário para a época em que foi implementado, mas se adapta ao contexto educacional atual.

Mais especificamente, o curso de Engenharia Elétrica na UnB é conhecido pela sua formação generalista com conhecimentos básicos de eletrônica, controle e automação, sistemas elétricos de potência e telecomunicações. São cinco anos de formação, com 80,5% da carga horária de matérias obrigatórias. O aprofundamento por meio das matérias optativas é de livre escolha do aluno. Dentro das obrigatórias, 18% são de teor prático, sendo um dos programas de graduação da instituição com maior quantidade de disciplinas em laboratório. A última grande reforma feita no fluxo e no currículo do curso foi em 2005. Será que a demanda dos engenheiros da década passada ainda é a mesma?

1.2 Objetivos do Projeto

Objetivo Geral: Fomentar o uso de abordagens educacionais atualizadas baseadas no aprendizado ativo dentro da Universidade de Brasília, mais especificamente nos cursos de engenharia.

Objetivo Específico: Exemplificar como o método *Project Based Learning* (PBL) pode ser implementado no contexto do curso de graduação em Engenharia Elétrica, mais especificamente na disciplina de Laboratório de Conversão de Energia da Universidade de Brasília.

2 Revisão Bibliográfica

Durante muito tempo, o ensino de engenharia nas universidades seguiu uma linha tradicional onde o professor é o foco das aulas e a matéria é apresentada aos alunos de uma maneira expositiva. Todavia, o mercado está cada vez mais exigente e buscando muito mais do que apenas pessoas com conhecimento técnico. As empresas buscam um perfil de engenheiro que saiba trabalhar em equipe, com clareza na comunicação e que, acima de tudo, tenha pensamento crítico, que consiga relacionar os conteúdos vistos de maneira coordenada para solução de problemas, ou seja, o mercado exige um vasto currículo multidisciplinar (National Academy of Engineering, 2004).

Para conseguir aproximar o futuro engenheiro dos desafios reais, os cursos devem proporcionar um ambiente que consiga simular o ambiente de trabalho, em que ele seja capaz de não apenas aplicar regras e instruções, mas sim de criar e aperfeiçoar novas regras, implementando projetos com possibilidades de melhorias para o meio em que vive (Villas-Boas, Booth, Mesquita & Lima, 2016).

No Brasil, observa-se um despertar sobre o tema "aprendizado ativo" que valoriza um cenário de protagonismo dos alunos. O COBENGE (Congresso Brasileiro de Educação em Engenharia) vem estimulando palestras, discussões e sessões dirigidas sobre o aprendizado ativo, que contam cada vez mais com a participação da comunidade acadêmica. Entre 2007 e 2014, 98 artigos foram escritos no país sobre o assunto. Interessante ressaltar que, das Instituições de Ensino Superior (IES) que mais contribuíram, a Universidade de Brasília está em segundo lugar com oito artigos (todos do departamento de Engenharia de Produção), ficando atrás apenas da Universidade Estadual de Feira de Santana, com catorze artigos (Oliveira, Pinto & Santos, 2015).

O aprendizado ativo permite aos alunos deixar de ser meros ouvintes e possibilita maior comprometimento e envolvimento dos mesmos. Oportuniza evolução do pensamento crítico, que consiste em análise, síntese e avaliação dos problemas propostos. Além disso, possibilita o engajamento dos estudantes em mais atividades durante o curso, em práticas como leitura, escrita e discussão. Em resumo, capacita-os para uma exploração de suas atitudes e valores de maneira mais aprofundada (Centea, Yuen & Mehrtash, 2016).

Uma das estratégias de aprendizado ativo é o *Project Based Learning*, que tem a proposta de apresentar um desafio aos alunos sem que eles tenham todo o conhecimento prévio para entregar uma solução. É preciso um esforço para coletar a informação necessária, analisar e discutir possíveis resultados. Dessa forma, como acontecerá em suas carreiras no futuro, torna-se crucial para o desenvolvimento do estudante que este aprenda a trabalhar em equipe (Michaluk, Martens, Damron & High, 2016).

Na maioria das matérias de um curso de Engenharia, as atividades dentro de sala costumam ser unidirecionais, onde o conhecimento é exposto ao aluno pelo professor durante a aula. Depois, fora de sala, o estudante tem um momento de prática por meio de exercícios propostos. O *flipped learning*, que significa aprendizado invertido, propõe uma mudança de ordem, trazendo as atividades práticas para dentro da sala de aula, como exemplificado na tabela abaixo:

Tabela 20. Abordagem do Método Tradicional e do Método Invertido

Método	Dentro de Sala	Fora de Sala
Tradicional	Aulas tradicionais (ênfase no professor)	Tarefas de aprendizagem e resolução de exercícios
Invertido	Tarefas de aprendizagem ativa e resolução de exercícios	Vídeos, ferramentas interativas e leitura (ênfase no aluno)

Não há uma tática padrão para o método invertido, e possui diversos estudos defendendo várias vertentes. Alguns estudos usam provas dentro de sala, outros defendem fora de sala. Há divergências pelo peso dos projetos e das provas. Todavia, todos mostram a mesma consistência: trabalho com conhecimento intelectual mais básico deve ser feito individualmente pelo aluno e atividades com nível mais elevado de raciocínio e análise dentro de sala (Bormann, 2014).

3 Desenvolvimento

3.1 Apresentação da disciplina

Para exemplificar o método PBL em uma matéria do curso de Engenharia Elétrica na Universidade de Brasília, foi escolhida para reformulação a disciplina do Laboratório de Conversão de Energia. A matéria possui uma carga horária total de 60 horas, distribuídas em 4 horas semanais durante 15 semanas. O conteúdo estudado é divido nos tópicos de circuitos polifásicos, transformadores e máquinas rotativas. A turma de alunos é dividida em 4 grupos de 3 pessoas (cada grupo em uma bancada). O laboratório possui seis máquinas de corrente contínua, oito máquinas assíncronas e oito máquinas síncronas. A bancada utilizada por cada grupo pode ser vista na Figura 1.

Figura 38. Bancada do laboratório com duas máquinas de corrente contínua acopladas.

3.2 Modelo atual

O modelo atual adotado no Laboratório de Conversão de Energia já utiliza o método invertido. Os alunos devem estudar previamente os roteiros dos experimentos e, ao chegar ao laboratório, devem se dirigir às bancadas, seguir as etapas descritas no roteiro, anotar as grandezas observadas (tensões, correntes, velocidades, etc), realizar os cálculos solicitados (potência, energia, rendimento, conjugado, etc), traçar os gráficos indicados (conjugado por velocidade, rendimento por carga, etc) e responder às questões relacionadas à interpretação dos dados obtidos. Os roteiros eram divididos por tipo de máquina elétrica (corrente contínua, indução, síncrona, etc).

Foi observado que alguns alunos seguiam o roteiro de forma mecânica, sem ter pleno conhecimento do que cada etapa significava, e muitas vezes obtiam os resultados e gráficos esperados mas sem entender o que significavam ou suas implicações.

Com base nessa avaliação, foi proposto aplicar PBL ao Laboratório de Conversão de Energia para que, em um ambiente com aplicação contextualizada e onde o aluno será o responsável por definir os resultados que devem ser alcançados e quais etapas devem ser realizadas para obtê-los, o processo de aprendizagem será mais eficaz, visto que exigirá uma postura mais ativa do estudante.

3.3 Modelo proposto

O método escolhido para reestruturar os roteiros do Laboratório de Conversão têm como propósito trazer uma ênfase maior ao aprendizado ativo. A maioria das matérias de cálculo já trazem como maneira de aprendizado a resolução de problemas contextualizados. Geralmente, os problemas requerem algum algoritmo aprendido na matéria, em que deve-se identificar os parâmetros necessários, substituí-los nas fórmulas e checar a resposta no gabarito. No sistema educacional atual, esses são os problemas em que os discentes desenvolvem seu aprendizado, um cenário bem distante de como problemas são encarados na vida real de um engenheiro.

No aprendizado por meio de projetos, o conteúdo geralmente não é dividido por assunto, mas sim por problemas. A construção do conhecimento não é estimulada pela matéria em si, mas sim pela aplicação e voltada para a mesma (Jonassen, 2011). Essa foi uma das mudanças da disciplina, que antes era dividida por tipo de máquina elétrica. A nova proposta recomendada neste trabalho sugere a divisão pelas seguintes aplicações:

- Bomba hidráulica (1 aula)
- Esteira industrial (2 aulas)
- Elevador (1 aula)
- Sistemas desconectados da rede de distribuição (1 aula)
- Academia sustentável (2 aulas)
- Compensador síncrono (2 aulas)

A divisão do conteúdo já traz para o aluno uma visão sobre o mercado. Em virtude do avanço da eletrônica de potência, as máquinas CC se tornaram soluções mais caras e não são tão utilizadas como antigamente. Por isso, devem ter menor destaque na disciplina. O aluno deve ter a visão do todo durante a sua graduação, mas o foco deve ser nos conteúdos de maior relevância na atualidade.

Os roteiros começam do mais simples até o mais complexo. Por isso, a primeira máquina a ser abordada é o motor de indução trifásico (MIT). São duas aplicações propostas para o MIT: bomba hidráulica e esteira industrial. Antes de começar o roteiro com as montagens que serão feitas e com as tabelas de medições, sempre tem um texto introdutório ao assunto. O propósito é abrir a mente do estudante na hora da prática, para ajudar na visualização dos fundamentos estudados na teoria serem vistos na prática.

Por exemplo, no roteiro da bomba hidráulica, deve-se fazer os ensaios a vazio e de rotor bloqueado para a obtenção dos parâmetros de circuito do MIT. Mas qual é o propósito de fazer ensaios para conseguir montar o circuito equivalente do motor? Quando isso é utilizado na prática? O contexto e o relatório visam estimular o aluno a desenvolver seu pensamento crítico em volta do experimento. No formato anterior da matéria, um questionário era feito ao final da aula, cobrando os dados e resultados encontrados na prática. Todavia, não dava tempo de realizar uma análise profunda sobre o assunto (o tempo destinado para essa atividade era em media 20 minutos e sem consulta de material auxiliar). Assim, o grupo não tinha tempo suficiente para discutir uma aplicação prática daquilo que tinha sido realizado.

Nesse novo contexto, também é proposto para o estudante fazer um código no MATLAB (ou software semelhante) que calcule os valores dos parâmetros do circuito por meio dos valores obtidos nos ensaios a vazio e de rotor bloqueado. Assim, o aluno consegue ter noção do conjugado nominal da máquina e do seu rendimento. Finalmente, um problema prático relacionado com o experimento é proposto: quando compensa substituir um MIT por um modelo mais eficiente? Suponha que tem um motor onde o valor das resistências do enrolamento de armadura seja metade dos valores das resistências encontrados no laboratório, mas esse motor é 30% mais caro. Qual será o novo rendimento do motor? Do ponto de vista econômico, compensa comprar o motor com melhor rendimento? Por meio de um exemplo que exija uma tomada de decisão de escolha entre dois motores, o aluno pode ir além de plotar gráficos e compará-los com a teoria (como era feito anteriormente). O discente consegue desenvolver seu pensamento crítico abordando vários aspectos de projeto, como demanda, custo econômico, tempo de retorno do investimento, vida útil do equipamento, conjugado nominal, instalações elétricas, rendimento, etc. Todos esses assuntos não são abordados diretamente no conteúdo de máquinas elétricas, assim o aluno, motivado a obter o conhecimento necessário para chegar à uma resposta, precisa buscar conhecimento adicional para elaboração do relatório. É esperado obter respostas variáveis dentro da mesma turma, considerando várias visões em torno de um problema amplo. As respostas serão baseados no semestre em que o aluno está, e também em suas experiências pessoais e profissionais, ou seja, conhecimentos prévios adquiridos. Esse é o propósito do método do PBL, que a pessoa consiga associar e organizar todo o seu conhecimento prévio para usar na resolução de um problema (Pazeti & Pereira, 2016; Tavares & de Campos, 2015).

Na mesma linha do exemplo citado, outros problemas práticos utilizando máquinas rotativas são mencionados como: sistemas desconectados da rede elétrica em áreas isoladas, elevadores e um projeto de academia sustentável utilizando geradores acoplados em bicicletas ergométricas. Detalhamento desses roteiros podem ser obtidos no trabalho de Reis (2017).

3.4 Abordagem didática

Ao longo dos roteiros, utilizou-se como estratégia aumentar gradativamente o nível de complexidade dos experimentos. Começou-se com os motores de indução, pela simplicidade. Além disso, no começo os roteiros também eram bem explicados e detalhados. O aluno precisava apenas se atentar aos detalhes que já estavam descritos no roteiro e executá-los. Para testar a capacidade de resolver problemas do grupo, os experimentos seguintes já não possuem esquemáticos de direta execução.

Assim, o grupo deve discutir e elaborar qual é a melhor estratégia para a execução daquele problema dentro do tempo de sala de aula. Além de aperfeiçoar o trabalho em equipe, o PBL visa desenvolver a solução criativa de problemas, sem todos os dados previamente informados, exatamente como ocorre na vida real (Villas-Boas, Booth, Mesquita & Lima, 2016). Os assuntos abordados não são de grande complexidade, especialmente para os alunos que realizaram o estudo prévio individual (método invertido). Sendo assim, a dificuldade é para que, no tempo proposto, o grupo consiga entrar em consenso no planejamento e na execução das coletas dos dados requisitados no roteiro.

Em alguns roteiros, é indicado o uso de software como o MATLAB para o estudante escrever um código e fazer uma simulação da máquina rotativa utilizada no experimento. Na disciplina, não foram indicados simuladores já com layouts prontos de máquinas rotativas, pois o propósito é justamente ter o processo de entender os circuitos e traduzir isso em forma de equação. O uso de simulações é muito importante em qualquer área da engenharia, pois permite a visualização de variações dos parâmetros dentro do sistema, ajuda no processo de acúmulo de conteúdo e ajuda no mapeamento cognitivo. Além disso, dá um *feedback* instantâneo para validar o conhecimento e compreensão do grupo. Em outras palavras, é mais uma ferramenta útil para potencializar a aprendizagem. É considerado uma prática de aprendizado ativo, pois o aluno interage com o software, escrevendo e alterando o código, sendo o protagonista da construção e da análise (Belhot, Figueiredo & Malavé, 2001; Jonassen, 2011).

Durante os experimentos, foram destacadas perguntas que não possuem um gabarito quantitativo. É esperado que o grupo consiga desenvolver a habilidade de argumentação e pensamento crítico, competência essencial para qualquer profissional no ambiente de trabalho. É esperado as identificações dos seguintes pontos durante a elaboração de um argumento (Jonassen, 2011):

- Qual é o problema?
- Quais são as variáveis envolvidas no problema?
- Quais as soluções possíveis?
- Qual a melhor solução para o contexto?
- Quais as evidências que sustentam meu argumento?
- O que pode ser argumentado contra minha escolha?

Ao final de cada experimento, os alunos devem preparar um relatório técnico, incluindo esses pontos. Feito os experimentos, ao final da disciplina, é proposto um desafio final. Desafios em grupo são mais motivadores do que simplesmente a exposição de um conteúdo, além da fixação ocorrer de maneira mais eficaz (Correia, Ghislandi, Lima, Mesquita, Amorim, 2016). Como o curso é ministrado em um laboratório, o desafio deve ser prático, sendo que as análises teóricas escritas foram cobradas e avaliadas durante os relatórios. É importante que o desafio seja alcançável, para não desmotivar a classe. Baseado em um dos roteiros, o desafio é deixar dois geradores síncronos em paralelo e esse conjunto em paralelo com a rede.

4 Resultados Experimentais

4.1 Teste dos roteiros

Cada experimento adaptado para PBL foi testado no laboratório para ver se o tempo seria adequado. É importante notar que os testes foram realizados por pessoas que já tinham conhecimento prévio dos esquemáticos e prática com as máquinas rotativas. O resultado mostrou que os roteiros propostos neste trabalho possuem potencial para serem implementados, pois o experimento mais longo tem duração média de 48 minutos. Provavelmente para os alunos o tempo será maior.

4.2 Desafio proposto

O desafio proposto para os alunos, de colocar dois geradores em paralelo e depois esse bloco em paralelo com a rede, não disponibiliza o esquema de ligação aos alunos. O grupo deve desenvolver uma solução com o equipamento disponível no laboratório. O tempo de execução de uma dupla foi de 40 minutos. O problema consegue analisar o desenvolvimento do aluno em organização, trabalho em equipe e compreensão da disciplina. O tempo investido fora do tempo convencional da aula para preparação junto com os colegas do grupo pode ser entendido como uma revisão de conteúdos estudados que não foram fixados no momento do experimento. Abordagens assim aproximam a disciplina do método invertido, mostrado na Revisão Bibliográfica deste trabalho.

5 Conclusão

Este trabalho visou mostrar como metodologias de aprendizado ativo podem ser implementadas nas matérias dos cursos de engenharia. No contexto do problema do Laboratório de Conversão de Energia, como se trata de matéria realizada em laboratório, é mais fácil observar a implementação dos métodos, mas nada impede que os mesmos princípios sejam usados em matérias consideradas completamente teóricas.

O laboratório tem como objetivo ajudar na formação profissional do engenheiro, incentivando o trabalho em equipe, já que as montagens são feitas em grupos. Também analisará o método invertido, que consiste em os universitários se organizarem previamente para chegarem na sala de aula com o conteúdo do dia previamente estudado e revisado. Os relatórios priorizam a argumentação e o relato dos caminhos usados pelo aluno para chegar na resposta, e não as resoluções em si. Além disso, possuem questões com simulações para potencializar o ensino. Todas essas são abordagens que valorizam o aprendizado ativo. Algumas já eram implementadas no contexto da Faculdade de Tecnologia da UnB, mas este trabalho demonstrou como esses métodos podem ser intensificados. Certas limitações foram encontradas para acrescentar outros roteiros em função do maquinário do laboratório. Por isso, as proposições foram destinadas mais à abordagem dos assuntos relacionados à máquinas rotativas do que à uma mudança total dos experimentos.

Este trabalho é uma proposta para algumas mudanças que podem ser implementadas, mas os resultados ainda precisam ser analisados. Quando o assunto é educação, é ambicioso afirmar que certo método funcionará perfeitamente para determinado contexto. É preciso tempo para testar como funcionará a longo prazo. Na bibliografia desse projeto, encontram-se vários exemplos positivos e negativos em diferentes locais do mundo onde o PBL conseguiu envolver mais os alunos de engenharia.

Educação é um processo amplo que engloba toda a sociedade e sua cultura. O ser humano aprende dentro do seu grupo familiar, organizações em que ele está vinculado e pessoas com que ele convive. Porém, a universidade tem obrigação na implementação de melhorias educacionais devido ao seu papel de espaço institucional legitimado para a formação da força de trabalho de uma nação. Este trabalho pretende oferecer propostas para que alunos possam ser cidadãos mais criativos nas soluções de problemas e que professores consigam ser essa peça chave que aceita as diferenças de aprendizagem de cada indivíduo e dá suporte de informação, motivando-os a vencer os desafios propostos (Moran, 2007).

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Implementation of PBL in a Social Education Programme at the Portucalense University

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Abstract

This study aims to describe the implementation of a PBL approach in a Social Education Programme at the Portucalense University (UPT) and to analyse student's perceptions about their participation in the project, namely, the main advantages and difficulties in regard to the PBL approach implemented in this context. The idea of the project emerged from the participation of the teachers in a training session about Active Learning, which provided the opportunity to develop this experience. In 2017/2018, three curricular units of the 2nd year of the programme, namely, "Adult Education", "Education for Health" and "Educational Mediation" developed an interdisciplinary project, based on the topic of addictive behaviours and dependencies. Students opinions were collected through a questionnaire, applied at the start and at the end of the project. The results, based on students' perceptions, suggest a positive view of the PBL experience. Student highlight creativity, problem solving skills, oral and written communication skills, project management skills, interpersonal skills and teamwork as the main skills developed during the PBL project.

Keywords: Project-based Learning (PBL), Interdisciplinarity, Socio-educational intervention.

Implementação de PBL no curso de Educação Social: resultados de um estudo piloto na Universidade Portucalense

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Resumo

Este estudo tem como principal objetivo descrever uma experiência piloto de implementação da metodologia de PBL no contexto da Licenciatura em Educação Social da Universidade Portucalense (UPT) e conhecer as perceções dos estudantes e no que se refere às potencialidades e dificuldades identificadas na implementação da metodologia de PBL neste contexto. A iniciativa surgiu no âmbito da participação das docentes numa formação pedagógica sobre Aprendizagem Ativa, resultando na oportunidade para desenvolver um projeto interdisciplinar no âmbito das unidades curriculares lecionadas pelas respetivas docentes, no 2º ano do respetivo curso. Deste modo, em 2017/2018, três unidades curriculares (UCs), nomeadamente, "Formação de Adultos", "Educação para a Saúde" e, por último, "Mediação Educacional", desenvolveram um projeto interdisciplinar, subordinado à temática da intervenção socioeducativa em comportamentos aditivos e dependências. Este foi o tema escolhido para o projeto piloto que procura integrar os resultados de aprendizagem específicos de cada uma das UCs, bem como as suas estratégias de avaliação, num projeto comum, que permite a articulação curricular e o desenvolvimento de um conjunto de competências transversais fundamentais. Os resultados sugerem um balanço positivo por parte dos estudantes envolvidos no projeto, destacando a criatividade, a capacidade de resolução de conflitos, competências de comunicação oral e escrita, competências ao nível de gestão de projetos, competências de relacionamento interpessoal e o trabalho em equipa como as principais competências trabalhadas e desenvolvidas durante o projeto PBL.

Palavras-chave: Project-based Learning (PBL), Interdisciplinaridade, Intervenção socioeducativa.

1 Introdução

De acordo com as orientações do *European Standards and Guidelines for Quality in Higher Education* (2015), o processo de ensino, de aprendizagem e de avaliação devem estar centrados no estudante, ou seja, o estudante deve desempenhar um papel ativo e autónomo na sua aprendizagem. Umas das metodologias de ensino que permite alcançar o desenvolvimento destas competências é a Aprendizagem baseada em Projetos ou, como é habitualmente designada na língua inglesa, *Project-based Learning* (PBL) (Powell & Weenk, 2003; Guerra, Ulseth, & Kolmos, 2017).

A aprendizagem baseada em projetos é uma metodologia de ensino e de aprendizagem ativa, centrada no estudante e no desenvolvimento de competências (Fernandes, 2011; Lima et al., 2017). As suas principais características são a ênfase na aprendizagem do estudante e o seu papel ativo (Fernandes, Mesquita, Flores & Lima, 2014), a resolução de problemas, a articulação entre a teoria e a prática, a interdisciplinaridade, trabalho cooperativo, a avaliação formativa e contínua (Fernandes, Flores & Lima, 2012).

Este estudo tem como principal objetivo descrever uma experiência piloto de implementação da metodologia de PBL no contexto da Licenciatura em Educação Social da Universidade Portucalense (UPT) e analisar o seu impacto no processo de ensino e de aprendizagem dos estudantes, nomeadamente, motivação ao longo do desenvolvimento do projeto, articulação entre a teoria e a prática, relacionamento interpessoal, gestão do tempo. A iniciativa surgiu no âmbito da participação das docentes numa formação pedagógica sobre Aprendizagem Ativa, resultando na oportunidade para desenvolver um projeto interdisciplinar no âmbito das unidades curriculares lecionadas pelas respetivas docentes, no 2º ano do respetivo curso.

Este estudo pretende conhecer as perceções dos estudantes e dos professores no que se refere às potencialidades e dificuldades que identificam na implementação da metodologia PBL, tais como, a perceção da eficácia deste modelo comparativamente com o modelo tradicional, no que diz respeito à aquisição de conhecimentos, perceção das dificuldades do processo e da superação das mesmas.

2 Contexto do Estudo

O estudo decorre na Universidade Portucalense Infante D. Henrique (UPT), uma instituição privada de ensino superior, certificada pela ISO 9001, reconhecida pelo Governo Português e pela Agência Portuguesa de Avaliação e Acreditação do Ensino Superior (A3ES). A UPT ministra diferentes cursos reconhecidos pela tutela, para o que conta com um corpo docente próprio habilitado e qualificado, distribuído por quatro Departamentos: Direito, Psicologia e Educação, Economia Gestão e Informática e Turismo Património e Cultura. A Licenciatura em Educação Social (LES) é um dos cursos de 1º ciclo que integra a oferta formativa do Departamento de Psicologia e Educação da UPT. O curso consagra uma formação de cariz teórico-prático que congrega saberes disciplinares das áreas educativas e das ciências sociais e do comportamento, contribuindo para o desenvolvimento do perfil profissional do futuro Educador Social. O Educador Social desempenha funções de formação, consultadoria, orientação, gestão e dinamização cultural em vários tipos de serviços, visando promover o desenvolvimento comunitário através da satisfação de necessidades formativas e informativas das populações. No âmbito das várias funções, o Educador Social polariza a sua atividade para o apoio psicossocial e educativo a indivíduos e grupos em situação de risco ou particularmente vulnerabilizados por condições pessoais e sociais deficitárias, designadamente grupos de idosos, membros de minorias étnicas, desempregados com dificuldades de adaptação sócio-laboral, imigrantes, sujeitos portadores de deficiência, mulheres vitimas de violência conjugal, e outros em situação de rutura social. Como contextos de atividade profissional, apontam-se, entre outros, os seguintes: Comissões de Proteção de Crianças e Jovens, Ludotecas e ATL, Equipas locais de intervenção, Lares comunitários de crianças e jovens, Lares de idosos, Centros de dia, Centros de acolhimento para vítimas de violência conjugal, Universidades sénior, Serviços de Formação ocupacional e Integração profissional, Estabelecimentos prisionais, Associações de animação cultural, Serviços de apoio familiar e comunitário, Programas comunitários de educação ambiental, Serviços de apoio a sujeitos portadores de deficiência, Serviços de reabilitação de toxicodependentes, Serviços de imigração, ONGS, IPSS, Programas e projetos de promoção da saúde.

2.1 Projeto PBL-LES: estudo piloto em 2017/2018

No ano letivo de 2017/2018, surgiu a oportunidade para o desenvolvimento de um projeto interdisciplinar no curso de Licenciatura em Educação Social devido à participação das docentes e autoras deste artigo numa formação pedagógica sobre Aprendizagem Ativa, promovida pelo *Centre for Excellence in Teaching* (CET-UPT) da Universidade Portucalense, em Julho de 2017.

Assim, desta formação resultou um plano de ação que envolveu a participação das respetivas docentes na organização e implementação de uma abordagem baseada em projetos interdisciplinares, no âmbito das UCs lecionadas no respetivo curso. Neste sentido, em 2017/2018, pretendia-se implementar projetos interdisciplinares com 3 UCs do 1º semestre do 2º ano e, posteriormente, no 2º semestre, com 5 UCs do 1ºano. A figura 1 ilustra a articulação entre as UCs de cada semestre e o projeto que se pretende desenvolver com os estudantes.

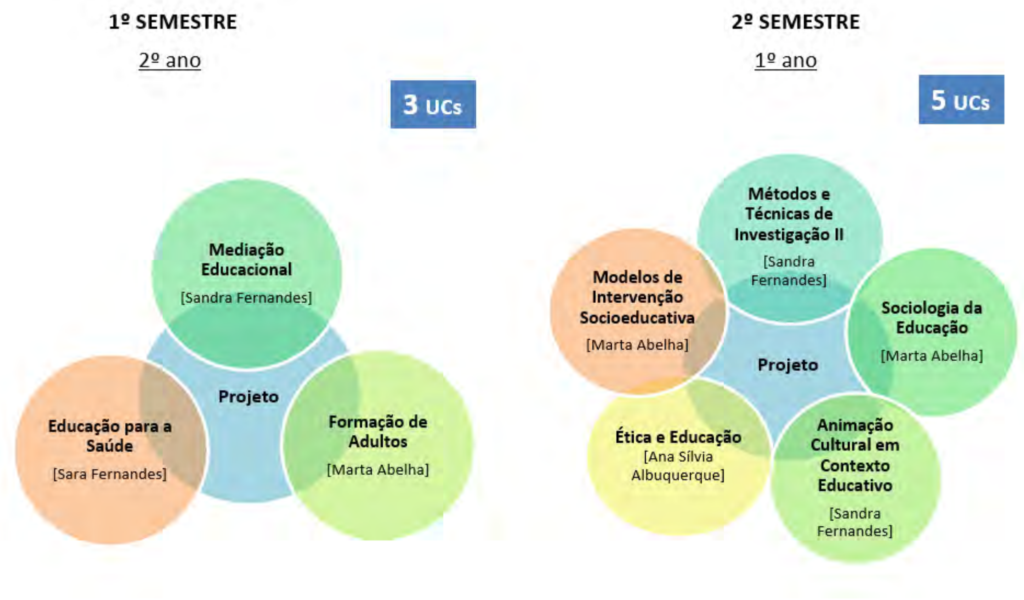

Figura 2: Ilustração dos projetos de PBL e respetivas UCs, no 1º e 2º semestre de 2017/2018

3 Descrição do Projeto do 1º semestre

Esta seção descreve, de forma mais aprofundada, a organização do semestre por parte das docentes, bem como alguma informação relativa a aspetos fundamentais do projeto, nomeadamente, as UCs que integram o projeto e respetivos resultados de aprendizagem, o tema selecionado para o projeto, a equipa docente e equipas de estudantes, *milestones* e elementos de avaliação do projeto.

Relativamente à organização do semestre, as docentes reuniram pela primeira vez em julho de 2017, antes do ano letivo iniciar, com o objetivo de atempadamente decidirem o tema do projeto a propor aos estudantes. Nesta reunião ficou também decidido os momentos de avaliação ao longo do semestre, foi elaborada uma grelha de avaliação das apresentações orais e a estrutura do trabalho escrito. Esta informação foi apresentada na primeira aula do semestre, na UC de Educação para a Saúde, com a presença das docentes envolvidas no projeto. As três apresentações orais previstas decorreram num momento único, no horário de aula da UC de Formação de Adultos, com a presença das três docentes. Os relatórios foram avaliados, num primeiro momento, por cada docente, sendo a nota final sido discutida numa reunião posterior. Para além das reuniões agendadas, sempre que necessário, foram estabelecidos contactos via e-mail.

3.1 Unidades Curriculares que integram o projeto

As três unidades curriculares (UCs) que integram o projeto são: Formação de Adultos, Educação para a Saúde e Mediação Educacional. A temática escolhida para o projeto piloto procurou integrar os resultados de aprendizagem específicos de cada uma das UCs, bem como as suas estratégias de avaliação, num projeto comum, que permite a articulação curricular e o desenvolvimento de um conjunto de competências transversais fundamentais. De seguida, apresentam-se alguns dos resultados de aprendizagem, que serão desenvolvidos no âmbito de cada UC que integra o Projeto.

No âmbito da UC de *Mediação Educacional*, espera-se que os estudantes sejam capazes de:

- Compreender o conceito de Mediação e as suas características
- Descrever as etapas que envolvem um processo de Mediação Educacional
- Conhecer o perfil e as competências de um Mediador Socioeducativo

- Identificar oportunidades de intervenção ao nível da Mediação Educacional em diversos contextos sociais e profissionais
- Participar, criativamente, na análise e criação de dispositivos de Mediação Educacional em diversos contextos sociais e profissionais

No âmbito da UC de *Formação de Adultos*, espera-se que os estudantes sejam capazes de:

- Entender a formação de adultos enquanto terreno privilegiado da intervenção sócio - educativa.
- Identificar competências-chave no desenvolvimento da Formação de Adultos, em diferentes contextos.
- Desenvolver competências de análise e conceção de programas de Educação e Formação de Adultos.

No âmbito da UC de *Educação para a Saúde*, espera-se que os estudantes sejam capazes de:

- Reconhecer a importância dos programas de educação para a saúde, apresentando exemplos de programas empiricamente validados em diferentes contextos.
- Refletir criticamente sobre programas de educação para a saúde, aplicando conhecimentos sobre saúde e bem-estar, bioética e educação
- Estruturar um programa de educação para a saúde, discriminando os diferentes elementos que o integram e selecionando estratégias de avaliação de eficácia adequadas.

3.2 Seleção do Tema do Projeto

O tema selecionado para o projeto piloto foi "Intervenção nos Comportamentos Aditivos e Dependências". A escolha deste tema foi resultado de uma análise prévia dos conteúdos programáticos de cada uma das UCs, procurando encontrar temáticas convergentes, e ao mesmo tempo, a busca de um tema atual, que suscitasse a motivação, quer dos estudantes, quer dos professores.

O comportamento Aditivo ou Dependência, é um conceito abrangente e que abarca toda e qualquer forma de comportamento em que o indivíduo, por uma razão que ele não controla, deixa que o seu corpo atue de uma forma "autónoma" (Rodrigues, 2015). De acordo com a ASAM (American Society of Addiction Medicine, 2011), a adição é uma doença crónica do sistema de recompensa cerebral, da motivação, da memória e dos circuitos cerebrais associados. A disfunção que se verifica nestes circuitos provoca manifestações biológicas, psicológicas, sociais e espirituais. Isto reflete-se no indivíduo que, de forma patológica, procura a recompensa e/ou o alívio através do uso de substâncias ou de outros comportamentos. Assim, os Comportamentos Aditivos podem estar ligados exclusivamente à dependência de substâncias químicas lícitas (tabaco, álcool, café, medicamentos) ou ilícitas (opiáceos, canabinóides, cocaína), como à dependência sem tóxicos, lícitos (jogo, alimentos, compras, sexo, tv, internet) ou ilícitos (roubo, incêndios).

A intervenção neste âmbito passa, de um modo geral, pela prevenção ou tratamento. A este nível, programas de intervenção têm vindo a ser desenvolvidos e validados empiricamente, demonstrando evidência científica.

3.3 Equipa Docente e Equipas de Estudantes

A equipa docente responsável pela dinamização do projeto PBL é constituída por 4 docentes do sexo feminino, com idades compreendidas entre os 35 e os 60 anos de idade. A maioria das docentes é doutorada na área de Educação, sendo apenas uma na área da Psicologia Clinica e da Saúde. De realçar que uma das docentes não lecionou no 1º semestre, contudo uma vez que o projeto se prolongará para o 2º semestre, considerámos de todo pertinente a sua participação nas reuniões de trabalho e nos momentos formativos.

As equipas de estudantes são constituídas por grupos de 2 a 3 elementos. No total, foram criados 5 grupos. Em termos de distribuição por sexo, 12 estudantes são do sexo feminino e apenas 1 estudante do sexo masculino. As idades dos estudantes estão compreendidas entre os 19 e 20 anos de idade. A maioria dos estudantes é residente na região do Porto.

3.4 *Milestones* e Avaliação do Projeto

A monitorização do projeto foi efetuada com base em *Miletones*, ou "pontos de controlo", que constituem momentos de apresentação do estado do desenvolvimento do projeto por parte dos grupos. Para além desse objetivo, visam proporcionar aos estudantes momentos de *feedback* sobre o desenvolvimento do projeto e uma oportunidade para o diálogo interdisciplinar, entre docentes e entre estudantes. Permite, igualmente, o esclarecimento de dúvidas e a clarificação de questões no âmbito do projeto e da integração das três unidades curriculares. Os pontos de controlo do projeto encontram-se na tabela seguinte.

#	Semana	Data	*Milestone*
1	Semana 2	2017.09.21	Apresentação do Projeto PBL-LES
2	Semana 3	2017.09.25	Aula Aberta: Comportamento Aditivos e Dependências
3	Semana 4	2017.10.02	Apresentação#1 (Submissão no Moodle)
4	Semana 10	2017.11.13	Apresentação#2 (Submissão no Moodle)
5	Semana 13	2017.12.04	Submissão do Relatório Preliminar (Moodle)
6	Semana 14	2017.12.11	Feedback do Relatório Preliminar (por cada uma das UCs)
7	Semana 15	2017.12.18	Apresentação Final e Discussão do Projeto (Submissão do Relatório Final)

Tabela 3: Calendarização dos *Miletones* do Projeto PBL-LES

As estratégias pedagógicas utilizadas no contexto de sala de aula foram combinadas entre o método expositivo e ativo. As aulas expositivas tiveram como finalidade apresentar os conteúdos programáticos que visavam o alcance dos objetivos de aprendizagem estabelecidos para cada UC. Concretamente, na UC de Educação para a Saúde, face ao objetivo que visa o reconhecimento da importância dos programas de Educação para a Saúde foram implementadas atividades de exploração de leitura. Com vista à reflexão crítica sobre programas de Educação para a Saúde foram analisados e discutidos programas já existentes e validados empiricamente, momentos de atividades de exploração de leitura, consulta de bases de dados digitais e de feedback do docente, face ao trabalho desenvolvido. Nas outras unidades curriculares, nomeadamente, em Mediação Educacional, para além das estratégias e atividades já referidas, o método do *role-playing* foi a estratégia privilegiada para o desenvolvimento e reflexão sobre processos de mediação em diferentes contextos e para a análise do papel e das competências do mediador. Os estudantes tiveram a oportunidade de *sentir e viver* "na pele" situações, conflitos e casos reais para os quais procuraram encontrar resposta através do processo de mediação.

No que se refere aos elementos de avaliação do projeto, estes encontram-se distribuídos em diferentes momentos, designados por *milestones*, ao longo do semestre. A nota final do grupo resulta de diversos elementos, com um peso diferente na classificação final do grupo. Os elementos de avaliação são os seguintes: Apresentação#1 (5%), Apresentação#2 (5%), Relatório Preliminar do Projeto (25%), Relatório Final do Projeto (35%), Apresentação Final e Discussão do Projeto (20%), Desempenho Individual no Grupo- auto e heteroavaliação (10%).

4 Apresentação dos Resultados

Os resultados que de seguida apresentamos emergem, por um lado, de uma avaliação de expectativas dos estudantes no início do projeto e, por outro, de uma avaliação das perceções dos estudantes, no final do projeto e da sua conclusão. Os dados foram recolhidos através da administração de um inquérito por questionário. O inquérito por questionário tinha como principal objetivo conhecer as perceções dos estudantes no que se refere às potencialidades e dificuldades que identificam na implementação da metodologia de PBL no contexto da Licenciatura em Educação Social.

4.1 Avaliação de Expetativas dos Estudantes

Os dados foram recolhidos, através do inquérito por questionário, após uma breve apresentação do projeto aos estudantes, em que foi divulgada a temática do projeto, sendo apresentados alguns exemplos de tipos de dependências e comportamentos aditivos. Foram igualmente apresentados os elementos de avaliação do projeto e respetivas ponderações, articulando as componentes de avaliação de cada uma das UCs, bem como o fornecimento de orientações sobre a estrutura do relatório do projeto e os *milestones* calendarizados ao longo do semestre, tendo em vista o apoio e a monitorização da aprendizagem dos estudantes.

O questionário com 5 questões abertas, foi preenchido em contexto de aula, na 2ª semana de aulas, após a apresentação pública do projeto. Relativamente à questão n.º 1 – "O que mais me motivou no projeto?" – sete dos 10 estudantes apontaram o tema "Intervenção nos Comportamentos Aditivos e Dependências" como o principal foco motivacional para o desenvolvimento do projeto. A possibilidade de desenvolver um projeto interdisciplinar que envolveria conteúdos curriculares de três UC´s foi referido por 5 dos estudantes como principal motivação para o desenvolvimento do projeto.

No que respeita à primeira parte da questão n.º 2 - "Quais são os aspetos que considera como mais positivos no desenvolvimento de um projeto, sustentado numa metodologia de PBL?" – 3 estudantes mencionaram a possibilidade de desenvolver um projeto sobre um problema existente na sociedade contemporânea e que carece de uma real importância socioeducativa. O facto de pré-existir uma possibilidade de estrutura orientadora do desenvolvimento do projeto foi outro dos aspetos considerados por 3 dos estudantes como mais positivos. O desafio de concretizar um projeto interdisciplinar (2 estudantes), a possibilidade de otimizar o trabalho desenvolvido no âmbito de três uc´s (2 estudantes) e o desenvolvimento de trabalho em equipa (1 estudante) foram outros dos aspetos considerados como mais positivos pelos estudantes. Em relação à segunda parte da questão n.º 2 - "Quais são os aspetos que considera como menos positivos no desenvolvimento de um projeto, sustentado numa metodologia de PBL?" – problemas ao nível da comunicação entre docentes e entre docentes e estudantes (2 estudantes), bem como dificuldades na gestão do tempo despendido na elaboração do projeto (2 estudantes) e algumas dúvidas respeitantes à avaliação (2 estudantes), foram apresentados pelos estudantes inquiridos como aspetos menos positivos no desenvolvimento de um projeto sustentado numa metodologia PBL

A questão n.º3 do questionário – "O que é que eu espero aprender com o projeto?", 4 dos estudantes referiram que esperavam aprender mais sobre a elaboração/construção de projetos de intervenção socioeducativa e aprofundar os seus conhecimentos sobre a temática "Intervenção nos Comportamentos Aditivos e Dependências", foi igualmente mencionado por 4 estudantes.

"Quais são as principais dificuldades que antevejo?" foi a questão n.º4 colocada aos estudantes. A ausência de prática na elaboração de projetos de natureza interdisciplinar foi apontada como principal dificuldade por 5 dos estudantes e o receio de uma eventual falta de adesão por parte do público-alvo a quem se destina o projeto foi outra das dificuldades apontadas por 4 dos estudantes envolvidos.

Finalmente, na questão n.º5 em que é dada oportunidade aos estudantes para que façam alguma sugestão ou observação, apenas 1 estudante mencionou dar a possibilidade de alterar a estrutura do projeto e que a nota final do projeto não fosse comum às três uc´s.

4.2 Avaliação Final dos Estudantes

Com o objetivo de avaliar a forma como decorreu o projeto ao longo do semestre, segundo a perspetiva dos estudantes, foi administrado um questionário na última aula do semestre, após a apresentação e defesa pública do projeto de cada um dos grupos de trabalho. Obtivemos resposta da totalidade de estudantes (N=13) do 2º ano da licenciatura em Educação Social que estiveram envolvidos no projeto piloto.

No questionário constituído por 37 afirmações foi solicitado aos estudantes que se posicionassem, indicando o seu nível de concordância relativamente a essas afirmações, utilizando uma pontuação de 1 a 4, em que: 1 = discordo; 2 = não tenho a certeza; 3 = concordo parcialmente e 4 = concordo totalmente.

Tendo em consideração as orientações do *European Standards and Guidelines for Quality in Higher Education* (2015), tal com referido anteriormente, de que o estudante deve desempenhar um papel ativo e autónomo na sua aprendizagem, a generalidade dos estudantes envolvidos no projeto piloto em PBL manifestou um grau de concordância total com a afirmação "Durante o semestre, desempenhei um papel ativo no grupo" (11 estudantes), tendo sido o item com maior pontuação em termos de média (3.92). "Sinto que a participação no projeto contribuiu para desenvolver a minha autonomia" (média = 3.38), foi apontado com um grau de concordância total por 7 dos estudantes e com um grau de concordância parcial por 3 estudantes". Estes resultados permitem-nos inferir que a experiência piloto de implementação da metodologia de PBL no contexto da Licenciatura em Educação Social da UPT contribuiu para incrementar os níveis de autonomia e participação ativas dos estudantes envolvidos.

De acordo com a literatura (Fernandes, 2011; Lima *et al*., 2017), a aprendizagem baseada em projetos é uma metodologia de ensino e aprendizagem ativa, centrada no estudante e no desenvolvimento de competências e a este propósito, os estudantes envolvidos destacaram como principais competências desenvolvidas ao longo do desenvolvimento do projeto em PBL, as seguintes:

- "A realização do projeto estimulou a minha criatividade", com uma média de 3.62;

- "Fui capaz de resolver os conflitos existentes no grupo e encará-los de forma positiva", com uma média de 3.54;

- "Com o projeto, adquiri e desenvolvi competências de gestão de projetos (capacidade de investigação, decisão, organização, resolução de problemas, gestão do tempo)", com uma média de 3.46;

- "Durante o semestre, melhorei as minhas competências de comunicação (oral e escrita)", com uma média de 3.46;

- "Considero que as competências de relacionamento interpessoal que desenvolvi são importantes para a minha formação profissional", com uma média de 3.46;

- O trabalho em equipa contribuiu para aumentar a minha motivação pela aprendizagem, com uma média de 3.23.

Podemos, assim, destacar que na perspetiva dos estudantes envolvidos, a criatividade, a capacidade de resolução de conflitos, competências de comunicação oral e escrita, competências ao nível de gestão de projetos, competências de relacionamento interpessoal e o trabalho em equipa foram as principais competências trabalhadas e desenvolvidas durante o projeto PBL.

A implementação do projeto PBL, no âmbito das três UCs envolvidas (Educação para a Saúde; Formação de Adultos e Mediação Educacional) permitiu, segundo os estudantes envolvidos, "ver a aplicação dos conteúdos em situações reais" (média = 3.23) "compreender melhor os conteúdos das UCs" (3.23) e compreender a articulação entre as UCs do semestre (média = 3.15), sendo que com uma média de 3.23 "o proposto foi [considerado] adequado".

A implementação de um projeto PBL, que num primeiro momento envolveu três unidades curriculares cuja a lecionação estava sob a responsabilidade de três docentes, requer por parte das docentes o desenvolvimento de trabalho colaborativo assente em lógicas de partilha, observação e reflexão crítica. Neste sentido, os estudantes consideraram que:

- "O projeto requer também trabalho em equipa por parte das docentes" (média = 3.62);

- "O feedback das professoras relativamente às apresentações e relatório foi útil" (média = 3.38);

- "As docentes das UCs do projeto informaram, regularmente, os alunos sobre as atividades do projeto" (média = 3.25);

- "As docentes prestaram o apoio necessário à concretização do projeto" (média = 3.17).

5 Considerações Finais

De uma forma geral, este artigo apresenta a descrição da implementação de uma abordagem de PBL no contexto de um curso de Educação Social e analisa as perceções dos estudantes sobre as potencialidades e dificuldades da sua participação no projeto.

De uma forma geral, é possível constatar que o balanço global dos estudantes é positivo, quer considerando as suas expetativas iniciais, quer as perceções finais, após a conclusão do projeto.

Numa fase inicial, os estudantes destacaram o tema do trabalho como um aspeto fundamental, que os motivou para a execução do mesmo, dado o facto de ser um tema que aborda um problema existente na sociedade contemporânea e que carece de uma real importância socioeducativa. Como principais dificuldades, destacaram o risco de se tratar de uma nova experiência para os docentes, podendo ter consequências menos positivas para os alunos, caso a experiência não corra de forma eficaz.

Relativamente aos resultados após a participação no PBL, os estudantes destacam a criatividade, a capacidade de resolução de conflitos, competências de comunicação oral e escrita, competências ao nível de gestão de projetos, competências de relacionamento interpessoal e o trabalho em equipa como as principais competências trabalhadas e desenvolvidas durante o projeto PBL. Estes resultados permitem confirmar algumas das potencialidades referidas na literatura sobre a aprendizagem ativa e o PBL (Fernandes, 2011; Lima *et al.*, 2017), centrada no estudante e no desenvolvimento de competências. É possível, ainda, reconhecer a importância da autonomia e do papel ativo desempenhado pelos estudantes na sua própria aprendizagem, aspeto que confirma uma das principais orientações do *European Standards and Guidelines for Quality in Higher Education* (2015).

Para além da melhoria do processo de aprendizagem dos alunos, esta abordagem de PBL tem igualmente aspetos positivos ao nível do trabalho e colaboração docente, sendo possível de destacar algumas das contribuições do projeto para a aprendizagem e desenvolvimento profissional das docentes envolvidas. É possível referir as dinâmicas de trabalho colaborativo docente, que atenuam eventuais receios face a metodologias de natureza inovadora, o aumento o nível de confiança sobre o trabalho a desenvolver, a articulação curricular, evitando a repetição e a redundância de conteúdos curriculares, dado que as atividades são coordenadas e as responsabilidades partilhadas de forma complementar pelas diferentes docentes envolvidas e, por último, o projeto contribui para a qualidade das aprendizagens dos estudantes, pois incentiva o correr riscos e a diversificar as metodologias de ensino.

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Potentialities of Inquire-Based Learning in the Study of Definite Integral in terms of Areas

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Abstract

This work presents a case study, in which were promoted activities in a learning environment, with interactive characteristics, giving priority to action, reflection and argumentation, as a way of encouraging the students' involvement in their realization. One of them was proposed, aiming at learning the definite integral in terms of area between curves, by solving a problem. Considering the answers that were being presented, a discussion was promoted, based on the inquire-based learning (IBL), in a virtual learning environment, using the forum and the Scientific Notebook software, for the construction of the graphics and also for the communication. The errors were used as a way to promote learning of those students who agreed to justify their answers, reviewing them based on the arguments that were being presented by the teacher or colleagues. Data analysis is ongoing, but preliminary results emphasize that the interaction provided by the use of technological resources was fundamental for the use of the virtual environment, in which oral and written communication promoted reflection and awareness of actions, confirming the occurrence of the learning of Definite Integral, by those involved. As a result, the problem initially proposed gave rise to other problems, related to other regions, whose area was also calculated. Thus, it became possible to approach the calculation of integrals of other functions, which arose due to the "mistaken" interpretations of the proposed problem, which was considered a determining factor for the achievement of the initially proposed objective. Preliminary results evidenced that IBL, in the way it was conducted, favored the occurrence of learning of all those involved, valuing the benefits of their participation, both for themselves and for their colleagues.

Palavras-chave: Active Learning; Engineering Education; Inquired-Based Learning; Definite Integral.

Potencialidades da Aprendizagem por Questionamento no Estudo da Integral Definida como Área de uma Região

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Resumo

Este trabalho apresenta um estudo de caso, em que foi promovida a realização de atividades em ambiente de aprendizagem, com características interativas, privilegiando a ação, a reflexão e a argumentação, como forma de incentivar o envolvimento dos estudantes na realização das mesmas. Uma delas foi proposta, visando à aprendizagem da integral definida no cálculo da área de uma região compreendida entre curvas, por meio da resolução de um problema. Considerando as respostas que iam sendo apresentadas, foi promovida uma discussão, com base na aprendizagem por questionamento (IBL), em ambiente virtual, com a utilização do fórum e do software *Scientific Notebook*, para a construção dos gráficos e também para a comunicação. Os erros foram utilizados como forma de promover aprendizagem daqueles estudantes que concordaram em justificar suas respostas, revendo-as com base nos argumentos que iam sendo apresentados pela professora ou por colegas. A análise, ainda em curso, já permitiu concluir que a interação propiciada pela utilização de recursos tecnológicos foi fundamental para a utilização do ambiente virtual, em que a comunicação oral e escrita promoveu a reflexão e a tomada de consciência das ações, confirmando a ocorrência de aprendizagem do conceito de Integral Definida, por parte dos envolvidos. Como resultado, o problema proposto inicialmente deu origem a outros problemas, referentes a outras regiões, cuja área também foi calculada. Assim sendo, tornou-se possível abordar o cálculo de integrais de outras funções, que surgiram devido às interpretações "equivocadas" do problema proposto, o que foi considerado fator determinante para o alcance do objetivo proposto inicialmente. Os resultados já obtidos evidenciaram que a IBL, na forma como foi conduzida, favoreceu a ocorrência de aprendizagem de todos os que se envolveram, valorizando os benefícios de sua participação, tanto para si mesmos, quanto para os colegas.

Palavras-chave: Aprendizagem ativa; Educação em Engenharia; Aprendizagem por Questionamento; Integral Definida.

1 Introdução

Neste trabalho apresenta-se o relato de uma atividade realizada, como parte de uma pesquisa em andamento, visando à aprendizagem da integral definida como área de uma região compreendida entre curvas. Além disto, para que seja possível justificar a ocorrência da aprendizagem, considerou-se importante abordar o que se entende por aprendizagem, como o ser humano aprende e como é possível participar satisfatoriamente deste processo, o que é imprescindível a cada educador. Dentre outros fatores, a aprendizagem depende de observação questionadora, de compreensão da realidade e de capacidade de argumentação e não se resume na memorização de conteúdos fragmentados e não contextualizados, que dependam apenas de capacidades perceptivas. (Becker, 1993).

No que se refere à Matemática, dada a dificuldade que muitos professores e estudantes ainda encontram ao lidarem com a aprendizagem de seus conceitos, é preciso, dentre outras ações, encontrar formas de escutar e motivar colegas e estudantes, incentivando-os a analisarem as próprias práticas. Com efeito, por um lado, o abandono de práticas pedagógicas consolidadas é muito difícil e somente pode ser desencadeado na reflexão sobre as mesmas e consequente tomada de consciência da necessidade e de possibilidades de mudança. Por outro lado, a construção do conhecimento, em cada nível do desenvolvimento humano, ocorre como consequência da interiorização das ações, o que só se dá conscientemente. Assim, espera-se que, com base no reconhecimento da necessidade de mudança, torne-se evidente como é possível sair do não saber para a tomada de consciência, em qualquer uma das posições em que se estiver, como professor ou estudante. (Freire, 1983).

Procurando proporcionar ambientes de aprendizagem em que possam ser consideradas concepções, expectativas e saberes dos estudantes, com uma proposta pedagógica cuja fundamentação é baseada na Epistemologia Genética (Piaget, 1978), tais ambientes de aprendizagem são concebidos levando em consideração o ponto de vista do estudante quanto ao seu papel, quanto ao papel do professor e ao que ambos pretendem com a disciplina ou curso. Todas as informações são levantadas por meio de questionamentos que visam também promover a reflexão sobre a importância de atividades interativas como colaboradoras de aprendizagem. Ao levar em conta as respostas dos estudantes, entende-se que uma proposta construtivista, baseada no diálogo, permite a aproximação entre Piaget e Freire, juntamente com outros autores, cujas pesquisas fornecem argumentos para justificá-la. Nesses ambientes, nem sempre é possível ouvir o estudante, mas é sempre possível escutá-lo, procurando valorizar o seu estudo, respondendo aos seus anseios com respeito e expectativa. Este, por sua vez, precisa sentir-se também desafiado, de forma que aceite envolver-se. Para Souza (2009), o estímulo às perguntas deve estar presente no trabalho em grupo, na aula presencial ou à distância, e em todos os outros contextos que fazem parte da disciplina ou curso. De fato entende-se que, quando isto ocorre, também ocorre aprendizagem que, em Matemática, que não dispensa boas justificativas e argumentos, indo além de simples traduções de operações realizadas. (Sauer, 2004).

Diante dessas considerações, na próxima seção, procura-se refletir brevemente sobre a atuação de professores, diante de exigências relacionadas ao Cálculo Diferencial e Integral. Neste cenário situa-se o campo de problematizações que emergem de questionamentos diante de problemas identificados e vivenciados por estudantes e professores preocupados com a aprendizagem de Matemática, em particular, de Cálculo Diferencial e Integral. Buscando fazer frente a tais exigências, destaca-se a necessidade de encontrar apoio em uma teoria de aprendizagem capaz de fundamentar novas ações e justifica-se a opção pela Epistemologia Genética de Piaget. A aprendizagem por questionamento (IBL) é apresentada como possibilidade de aprendizagem ativa, em consonância com os pressupostos teóricos assumidos, por meio da qual foi realizada a prática pedagógica, descrita na seção 3. A mesma foi planejada para ser realizada em ambiente virtual, com apoio do software matemático *Scientific Notebook*, tendo sido desencadeada com a proposta de resolução de um problema, envolvendo o cálculo da área de uma região, usando integral definida. Durante o desenvolvimento da prática, a IBL proporcionou a realização de ações que forneceram dados para análise e discussão de resultados já obtidos. Finalmente, na seção 4, retoma-se o plano, revendo-o e reconstruindo-o, procurando evidenciar algumas conclusões que também apontam para a necessidade da continuação da pesquisa, a fim de confirmar ou esclarecer questões que emergem de novas possibilidades destacadas.

2 Aprendizagem de Matemática e a Aprendizagem por Questionamento (IBL)

O conhecimento nasce toda vez que o ser humano se apropria do seu pensar. De acordo com os pressupostos psicopedagógicos que emergem desta concepção, a tendência do professor é a de se colocar como mediador do processo de aprendizagem, o estudante como interagente e o conhecimento como resultado da ação e das interações. As ações docentes terão propósito desequilibrador, provocando conflitos e situações problemáticas que estimulem o pensamento e levem o estudante a refletir sobre sua ação.

No caso específico da Matemática, para a qual se direciona a atenção neste trabalho, os atos próprios do "fazer matemático" como experimentar, visualizar e interpretar, prever, induzir, generalizar, abstrair e demonstrar nem sempre se constituem como apropriações para os estudantes.

A apresentação discursiva, em ambientes educacionais ainda é muito presente em salas de aula. Entretanto, nos últimos anos, intensas discussões, estudos e publicações têm confirmado a ineficácia do ensino que não envolve o estudante, ativamente, na construção do próprio conhecimento, de forma a contribuir para o desenvolvimento de competências requeridas na própria formação, além da capacidade de comunicação. (Lima, Andersson, & Saalman, 2017). Tudo isto tem gerado a adoção de posturas diferenciadas, que possibilitem a formação de pessoas que pensem, que participem e argumentem, que sejam capazes de resolver problemas e de propor soluções, aperfeiçoando-as e adaptando-as a cada nova situação.

Quando se fala em Matemática, é preciso lembrar que a mesma possui identidade ímpar, fundamentação lógica imprescindível, linguagem particular e exige a formalização de todos os conceitos construídos em cada etapa, adequada a cada nível de desenvolvimento cognitivo. O conhecimento matemático é, por natureza, encadeado e cumulativo. Do mesmo modo que na evolução das ideias, também no ensino, os conceitos devem ser introduzidos, construídos ou reconstruídos, à medida que vão sendo solicitados, à medida que o estudante esteja em condições de apreciá-los crítica e compreensivamente. Os conceitos, desde os primeiros, referentes aos números, às operações algébricas e às suas propriedades são objetos sobre os quais é necessária uma efetiva e sólida construção. Portanto, tudo isto só pode ocorrer mediante a ação de quem está aprendendo e não mediante a observação da ação do professor.

Assim sendo, entende-se que as ações reflexivas constituem princípios fundamentais para aprendizagem de matemática, que derivam das expressões escrita e falada, além da discussão fundamentada sobre os significados dos conceitos. Com efeito, quanto mais se "ensina", mais se "aprende"; quanto mais se procura argumentos para convencer os estudantes de determinado ponto de vista, mais propriedades se encontra. Sendo assim, é importante, enquanto educadores, possibilitar que os estudantes também tenham oportunidades para escrever ou falar, justificando e argumentando sobre como estão pensando.

Com tais pressupostos, entende-se que a abordagem IBL, quando bem compreendida e conduzida, por parte do professor, é uma possibilidade colaboradora no desenvolvimento das competências referidas. É preciso que o papel do professor deixe de ser reconhecido como o de transmitir informações, para proporcionar a aquisição de competências de argumentação, escrita, leitura, questionamento, resolução de problemas, criatividade, pensamento crítico. raciocínio lógico e trabalho em grupo, dentre outras.

Além disso, espera-se formar cidadãos que saibam valorizar as relações interpessoais e que se desenvolvam intelectualmente ao longo da vida. Tudo isso, pressupõe uma aprendizagem ativa, ao invés da passividade de apenas assistir aulas. Bonwell & Eison (1991, p.2), por exemplo, consideram cinco características para uma aprendizagem ativa: i) os estudantes estão empenhados na aula e não são somente ouvintes; i) é colocada menor ênfase na transmissão de informações e maior ênfase no desenvolvimento das capacidades dos estudantes; iii) os estudantes estão envolvidos em pensamentos de elevado nível cognitivo tais como análise, síntese e avaliação; iv) os estudantes estão envolvidos em atividades tais como ler, discutir e escrever; v) é colocada grande ênfase na exploração de valores e atitudes.

Em um verdadeiro ambiente de aprendizagem ativa, o papel do professor é o de colaborador ou orientador da aprendizagem, ou seja, orienta as descobertas e direciona as interações dos estudantes. Por outro lado, o papel dos estudantes é o de "exploradores". No contexto da aprendizagem ativa os estudantes têm grande responsabilidade nas suas próprias aprendizagens. Para tanto, há que se destacar a necessidade de que sejam promovidas estratégias de ensino e aprendizagem que requeiram suas participações ativas. Uma delas é a IBL, em que o professor, além de questionar, procura motivar a curiosidade, despertando o reconhecimento, por parte dos estudantes, da importância de fazer perguntas.

Postman & Weingartner (1981) afirmavam que a arte e a ciência de formular perguntas é a habilidade mais importante que o homem desenvolveu até hoje. O questionamento está na base da habilidade humana. Dillon, um cientista norte-americano que trabalhou muito o questionamento em contexto educativo na década de 80, também dizia: "O processo mental associado à elaboração de uma pergunta estimula o raciocínio que pode contribuir para o desenvolvimento intelectual de quem a formula". (Dillon, 1986, p.333).

Na IBL destaca-se que o verdadeiro diálogo instaura-se como possibilidade de coordenação de pontos de vista, sendo conduzido pelo interesse em compreender o outro, gerando relações de cooperação. Estas, por sua vez, estreitamente relacionadas ao processo de descentração, opõem-se, do ponto de vista intelectual, ao egocentrismo ou à centração e, no plano social, conduzem à solidariedade, liberdade e autonomia. (Sauer, 2004). As discussões, mesmo quando não se constituem como atividades obrigatórias, permitem refletir sobre possibilidades de identificar dificuldades, melhorar a compreensão, esclarecer dúvidas e socializá-las, propiciando, dessa forma, benefícios a todo o grupo envolvido, sempre que houver interesse. Com efeito, tais discussões possibilitam o desenvolvimento cognitivo e compete ao professor incentivar a participação de todos, valorizando todas as contribuições, seja através de questionamentos ou conclusões, ou ainda, por meio de sugestões de aperfeiçoamento para questões próprias ou de colegas. (Saltiel, 2006).

Ao escrever ou falar sobre o que está pensando, o sujeito pode agir sobre o meio, sobre algum objeto, algum conteúdo, sobre as próprias ações, interagindo com outros sujeitos e, ao fazer isso, ele tem condições de voltar-se sobre si mesmo e, por um processo de tomada de consciência, desenvolver-se. (BECKER, 2001).

Com tais pressupostos, na próxima seção é descrita uma prática pedagógica, realizada por meio da IBL, em que são destacados aspectos importantes para o bom êxito desta estratégia.

3 Uma Prática Pedagógica

Favoráveis a uma educação sintonizada com os pressupostos teóricos acima destacados tem-se procurado, em atividades docentes, promover a participação – intervenção, a partir da formulação de problemas que possam ser discutidos por todos aqueles que estiverem motivados e dispostos a construir seu próprio percurso de aprendizagem. Na realidade, a possibilidade de modificação da tradicional sala de aula presencial, baseada no baixo nível de participação oral dos estudantes, na ênfase em atividades solitárias, na aprendizagem mecânica de conteúdos como principal objetivo do ensino, na distribuição do conhecimento, depende de vários fatores, mas o mais importante, em relação ao que se entende por aprendizagem ativa, está relacionado a uma atitude de ambos, professor e estudante, quererem e concordarem com os benefícios destas modificações. Tais modificações exigem uma ampla revisão do papel do professor, mas também do estudante. Abordagens construtivistas têm sugerido a presença frequente do professor como orientador, questionando, argumentando, aceitando sugestões construtivas, rejeitando atitudes negativas, valorizando todas as respostas, mas, também, atitudes como respeito, generosidade, humildade, coragem, confiança e tantas outras. Enfim, converter o currículo, a partir das questões do estudante, em algo que faça sentido para ele e lhe traga satisfação. Ao estudante caberá, como agente ativo deste processo, envolver-se e procurar reconhecer os benefícios de sua participação.

Ciente de que uma boa teoria de aprendizagem pode e deve ser comprovada e tendo em vista que todas estas reflexões só se farão sentir quando colocadas em prática, têm-se realizado algumas atividades com o objetivo especial de melhor interagir com os estudantes, visando conhecer seus interesses e melhor interpretar suas respostas, tratando erros como possibilidades de desenvolvimento, enfim, procurando promover melhores condições de aprendizagem. Numa destas atividades, que se passa a descrever, em parte, foi utilizado um ambiente virtual de aprendizagem (AVA), durante o desenvolvimento de uma disciplina de Cálculo Diferencial e Integral. Tratava-se de uma turma de trinta estudantes, aproximadamente, dos quais, todos participaram das discussões, no mínimo, uma vez. A questão discutida está ligada ao conceito de integral definida e sua aplicação ao cálculo de áreas. São omitidos alguns detalhes das intervenções, irrelevantes para aqueles que não estão familiarizados com alguns conceitos específicos do Cálculo, o que não deverá prejudicar a boa compreensão das ideias que se propõe compartilhar neste trabalho.

São conhecidas, desde a antiguidade, diversas fórmulas para o cálculo de áreas de regiões planas. Além destas, áreas de algumas regiões limitadas por segmentos de reta e algumas curvas, também foram calculadas antes do surgimento do Cálculo Diferencial e Integral. Porém, a partir do Cálculo, a medida exata da área de uma região limitada por curvas, pôde ser determinada, com a utilização da "integral", um dos seus conceitos fundamentais, segundo o qual, "se *f* é uma função contínua e positiva num intervalo limitado, então a integral definida de *f*, neste intervalo, é a área da região compreendida entre o seu gráfico, as retas verticais que passam pelos extremos deste intervalo e o eixo horizontal do plano cartesiano". (Stewart, 2008).

Assim, por exemplo, o problema de se calcular a área da região compreendida entre o gráfico de uma função *f*, contínua e positiva no intervalo (0,1) pode ser resolvido calculando-se a integral de *f*, de 0 até 1, que é representada por $\int_0^1 f(x)dx$.

Imagine que o resultado seja A. Então, pode-se interpretar A unidades quadradas, como sendo a área da região em questão. Ou ainda, se *f* e *g* são duas funções contínuas, tais que *f* é maior do que *g* num dado intervalo, neste caso, (0,1), então a área da região compreendida entre seus gráficos, neste intervalo, pode ser obtida calculando-se

$$\int_0^1 (f(x) - g(x))dx.$$

Nessa discussão, foram consideradas as funções *f* e *g*, representadas graficamente na Figura 1.

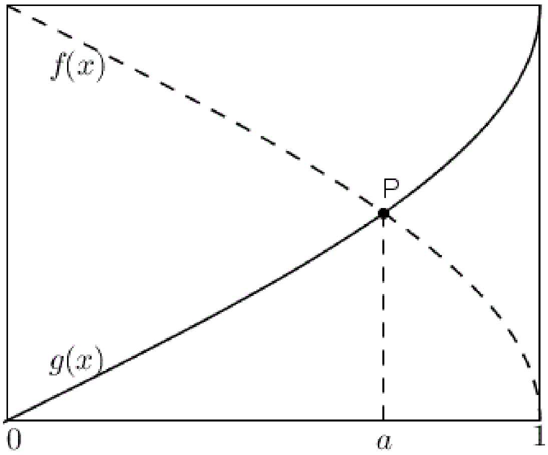

Figura 1. Gráficos das funções *f* e *g*, no intervalo (0,1), que se cruzam no ponto de abscissa *a*.

O problema proposto consistiu em determinar a área da região compreendida entre *f* e *g* e o eixo horizontal. Orientou-se que fosse resolvido à distância e apresentado no fórum específico, no AVA, paralelamente ao desenvolvimento da disciplina, que estava tratando de métodos para o cálculo de integrais de funções. Perguntas foram incentivadas, deixando-se claro que as dúvidas deveriam ser apresentadas para que pudessem ser esclarecidas e discutidas, justificando-se como de responsabilidade e de proveito para todos os interessados. Todos os estudantes, em graus variados, se envolveram na discussão, perguntando ou respondendo aos colegas e o que se pretende destacar, a seguir, está relacionado às diversas interpretações que foram feitas, bem como consequências, em termos de aprendizagem, decorrentes da discussão promovida, nas condições planejadas.

Em primeiro lugar, destaca-se que a área solicitada pode ser obtida calculando-se

$$\int_0^a f(x)dx + \int_a^1 g(x)dx.$$

Entretanto, como resposta, obteve-se, além desta, outras que se julga importante considerar, o que, de fato, foi feito, analisando-as com os próprios estudantes que as apresentaram, além de outros colegas que manifestaram interesse em participar com comentários. De uma forma ou outra, todos responderam. Assim sendo, para discuti-las neste trabalho, optou-se por destacar algumas das respostas recebidas, que se referiam a outras regiões, diferentes de r_1, aquela que estava sendo objeto de análise. Como consequência, suas áreas, resultantes de cálculos de diferentes integrais, são diferentes da área de r_1. As mesmas são apresentadas na Figura 2, tendo sido designadas, respectivamente, por r_2, r_3, r_4, r_5 e r_6, a saber:

r_2 compreendida entre os gráficos das duas funções *f* e *g* e a reta vertical *x* = 0 (eixo *y*);

r_3, compreendida entre os gráficos das duas funções *f* e *g* e a reta horizontal $y = f(0)$, no intervalo (0,1);

r_4, compreendida entre os gráficos das duas funções *f* e *g* e a reta vertical *x* = 1;

r_5, compreendida entre o gráfico de *f* e o eixo x, no intervalo (0,1);

r_6, compreendida entre o gráfico de *f*, a reta x = 1 e a reta $y = f(0)$.

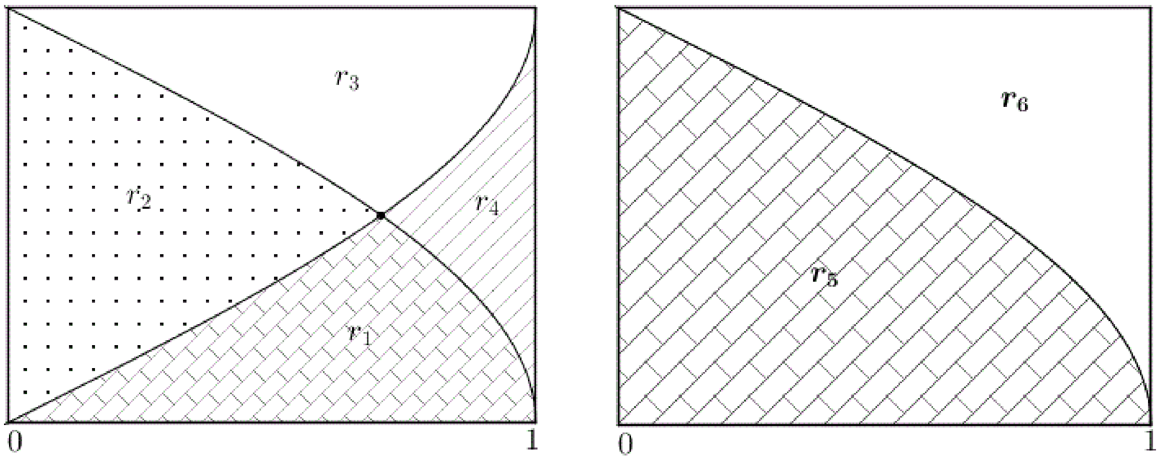

Figura 2. Região $\boldsymbol{r_1}$ e outras que ficam visíveis no intervalo (0,1), em que *f* e *g* estão sendo consideradas.

Durante a discussão todas as respostas eram comentadas ou questionadas e, em todos os casos, outros colegas manifestavam-se sugerindo uma possibilidade de reformulação, aperfeiçoada ou não. Na verdade, todas as regiões possíveis de serem identificadas no gráfico dado, além de outras (inexistentes) que lhe foram acrescidas, tiveram suas áreas calculadas. De maneira geral, não houve dificuldades significativas em relação ao cálculo de nenhuma das integrais que surgiram no decorrer da discussão. Estes sempre foram realizados com a utilização dos métodos que estavam sendo estudados paralelamente, ou mesmo com o auxílio do *software*. Na Tabela 1, a seguir, são apresentadas algumas respostas dos estudantes, ao problema proposto, lembrando aqui, que o mesmo foi proposto nos seguintes termos: “calcular a área da região delimitada pelos gráficos das funções *f* e *g*, apresentadas na Figura 1, e pelo eixo horizontal.”

Tabela 1. Algumas respostas apresentadas para o problema proposto

Estudante	Resposta apresentada no fórum de discussões
Fer	A área da região compreendida entre *f*, *g* e o eixo horizontal pode ser calculada como: $1-\left(\int_0^a f(x)dx+\int_a^1 g(x)dx\right)$ pois *f* é superior a *g* na maior parte do intervalo.
Ren	Temos que calcular a área adicionando as integrais de *f* e *g*, desta forma: $\int_0^1 f(x)dx+\int_0^1 g(x)dx$.
Sil	$\int_a^1 f(x)dx-\int_a^1 g(x)dx$ pois *f* é superior a *g* na maior parte do intervalo.
And	Para fazer isso, precisamos dividir em dois intervalos: (0,a) e (a,1). Observamos que no primeiro intervalo, *g* é maior do que *f* e no segundo, *f* é maior do que *g*. Então a área ficaria assim: $\int_0^a (g(x)-f(x))dx+\int_a^1 (f(x)-g(x))dx$
Joc	Como *g* é maior do que *f*, calculamos a área subtraindo as integrais: $\int_0^a (g(x)-f(x))dx$.
Fel	$\int_a^1 f(x)dx+\int_a^1 g(x)dx$
Mar	A área solicitada pode ser calculada fazendo $\int_0^a f(x)dx+\int_0^a g(x)dx$

Com base nas respostas destacadas, dentre outras, foi possível perceber a dificuldade de compreensão do conceito envolvido, bem como de expressão, que revelaram, por vezes, a ausência do raciocínio formal, dada a dificuldade de interpretação do problema proposto. De fato, pode-se interpretar as respostas destacadas na Tabela 1, como respostas a outras possíveis perguntas. Por este motivo, considerando o interesse já mencionado, de incentivar o desenvolvimento do raciocínio de cada um, ao procurar explicar como pensou, cada resposta era questionada e comentada pela professora, que, muitas vezes foi seguida por colegas que acessavam o fórum. Mesmo que a intenção fosse a busca pela resposta correta, os questionamentos se mostraram provocadores, pois sempre retornava alguma resposta.

Assim, por exemplo, após um período em que alguns questionamentos já haviam sido feitos, uma pergunta feita pela professora, foi direcionada a todos: "*separem cada uma das integrais que estão propondo e analisem a região cuja área cada uma representa*". Esta pergunta foi bastante colaboradora, pois, a partir dela, vários equívocos foram percebidos e mencionados pelos autores. Por exemplo, *Ren*, *Sil*, *Joc*, *Fel* e *Mar*, disseram ter percebido que estavam considerando somente um dos intervalos (0,a), ou (a, 1), ou mesmo (0,1), porém, de forma que outras regiões fossem envolvidas. Para estas respostas, foi solicitado que apresentassem um gráfico, em que aparecesse a região cuja área foi calculada por meio da integral que apresentaram. Esta solicitação mostrou-se bastante motivadora, pois foi a partir daí que as outras regiões, mostradas na Figura 2, passaram a aparecer. Por exemplo, a resposta apresentada por *Fer* foi bastante discutida pelos colegas que tiveram dificuldade em interpretar a subtração proposta e o papel da função dada por "1", na proposta apresentada. Este explicou aos colegas, no fórum, que $y = 1$ "fechava" a região, o que considerava necessário para a resolução do problema proposto.

Com base nisso, então, perguntou-se como deveria ter sido cada uma das perguntas, para cada uma das respostas apresentada. Novamente, ocorreu um ponto alto da discussão, ao receber os retornos, cujos recortes são apresentados na Tabela 2.

Tabela 2. Perguntas que foram respondidas por meio das integrais apresentadas na Tabela 1

Estudante	Pergunta respondida
Fer	Qual a área da região compreendida entre os gráficos de f e g e a reta horizontal $y = 1$? (ou seja, r_3).
Ren	Qual a área da região compreendida entre os gráficos de f e g? (ou seja, $r_1 + r_2 + r_4$).
Sil	Qual a área da região compreendida entre os gráficos de f e g e a reta vertical $x = 1$? (ou seja, r_4).
And	Qual a área da região compreendida entre os gráficos de f e g, o eixo y e a reta vertical $x = 1$? (ou seja, $r_2 + r_4$).
Joc	Qual a área da região compreendida entre os gráficos de f e g e o eixo y? (ou seja, r_2).
Fel	Qual a área da região compreendida entre o gráfico de f e o eixo x no intervalo (a,1)? (ou seja, a parte de r_1 , que fica entre a e 1).
Mar	Qual a área da região compreendida entre o gráfico de g e o eixo x no intervalo (0,a)? (ou seja, a parte de r_1 , que fica entre 0 e a).

Optou-se por encerrar a discussão quando um dos estudantes apresentou, de forma clara, as regiões r_1 , r_2 , r_3 , r_4 , r_5 e r_6 , observadas no gráfico, a partir do problema proposto, bem como as respectivas áreas, devidamente calculadas, com o que todos concordaram. Mereceu destaque a iniciativa, bem como a criatividade de sua intervenção, ilustrando seu raciocínio, ao apresentar todas as regiões que se tornaram objetos de análise, utilizando um recurso computacional que permitiu identificar cada uma das regiões o que certamente auxiliou, em alguns casos, na compreensão ainda não adquirida até então.

Foi possível observar, no caso deste estudante, o emprego espontâneo, num problema complexo, das operações combinatórias, diante de uma situação que motivou sua utilização.

> Salienta-se que o problema foi proposto sem a previsão destes resultados, porém, com a intenção de seguir os estudantes no caminho que escolhessem para discutir, incentivando-os a se envolverem e a reconhecerem os benefícios desse envolvimento. Indiscutivelmente, tratam-se de aprendizagens diferenciadas, com ritmos e tempos diferenciados, porém, conforme os pressupostos assumidos, foi possível promover aprendizagem.

4 Conclusão

São muitas as possibilidades de intervenção que o professor, no papel de mediador, tem ao seu dispor. Converter dúvidas ou conhecimentos demonstrados, a partir de respostas apresentadas, em algo que faça sentido para o estudante e, consequentemente, transformá-las em conteúdo, é uma delas. Além disto, ciente de que o fenômeno da interatividade pode ocorrer independentemente da presença do computador, não se pode ignorar a diversidade de interação hoje permitida pela utilização de recursos da tecnologia disponível. É preciso reconhecer, com isso, uma boa oportunidade de aproveitar os recursos tecnológicos para promover melhores condições de aprendizagem de matemática. As trocas de mensagens nos fóruns de discussão, aliadas à possibilidade de anexar arquivos, permitem um aprofundamento das discussões realizadas em sala de aula, contando com a participação de um maior número de interessados, indiscutivelmente. Observa-se que estudantes que dificilmente questionam ou participam de discussões em sala de aula, não raro enviam suas contribuições à discussão via fórum. Nos raros casos de não familiaridade com os recursos da internet, é rápida a aquisição dos conhecimentos necessários. As facilidades apresentadas por alguns *softwares* matemáticos permitem que, desde o início, possam ser utilizadas abordagens numéricas, algébricas, gráficas e verbais.

Além disso, entende-se como benefícios da utilização da estratégia IBL:

- ✓ a utilização da escrita como colaboradora para a compreensão do conceito explorado;
- ✓ a possibilidade de (re)construção de outros conceitos envolvidos e supostamente já adquiridos anteriormente como, por exemplo, o de área de uma região;
- ✓ a possibilidade de tratar dos conceitos e aplicações, independentemente das atividades manipulativas;
- ✓ melhores condições de trabalho em termos de cooperação e colaboração;
- ✓ a possibilidade de acompanhar os estudantes no caminho que escolherem, com base nos conhecimentos que apresentam;
- ✓ a possibilidade de detectar dificuldades que nem sempre podem ser reconhecidas em ambientes tradicionais de ensino, priorizando o processo de abstração do próprio aluno, a partir de suas próprias ações e da tomada de consciência das mesmas, bem como dos próprios erros.

Sem dúvida, nem todos os estudantes são atingidos pelo estímulo que promove o desejo de participar, de tentar explicar como chegaram às suas conclusões ou de verbalizar como estão pensando sobre determinado problema enquanto raciocinam. Entretanto, continuar neste caminho de análise e reflexão sobre os benefícios decorrentes de atividades de interação parece ser a melhor opção. E a IBL, como fonte de aprendizagem ativa, tem-se confirmado com potencial para promover o desenvolvimento de competências imprescindíveis na educação em Engenharia. Entende-se como Castelhano (2014), que o desenvolvimento profissional se manifesta na vontade de inovar e de melhorar as práticas, de forma a ampliar as possibilidades de aprendizagem, o que se procurou demonstrar com este trabalho.

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Teaching and learning of Entrepreneurship: student's perceptions in Higher Education

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Abstract

Aware of the challenges of today's society, the Portucalense University (UPT) has implemented a curricular unit (UC), called "Entrepreneurship", transversal to all curricula of the first cycle courses of its training offer. This UC, placed in the 3rd year of undergraduate courses, is based on a project-based learning methodology, which takes place over a period of 1 semester, in a total of 17 sessions, which can take different pedagogical formats: lectures, mentoring, seminars and pitchs. The students, from different study programmes of UPT undergraduate degrees, make teams of four students (maximum). Each team aims to develop an innovative business idea that demonstrates economic and financial viability. This study seeks to analyse students' perceptions about the curricular unit of Entrepreneurship. To do this, in the 2016/2017 academic year, a questionnaire was applied to the students (N = 131). The questionnaire included a set of 40 questions, structured according to the Likert scale model, resulting from an existing conceptual framework in the field of PBL and evaluation practices already developed in the context of Higher Education. The questionnaire covers topics such as learning and skills developed by the students, teamwork, the role of the teacher, the evaluation process of the students and, in general, the evaluation of the project as a teaching and learning methodology. The questionnaire also includes a final question about the compulsory or optional nature of this curricular unit. The results are discussed, exploring the pedagogical implications for Higher Education intervention, suggesting the need for a greater reflection and discussion about the relevance and the nature of the projects for each one of the different areas of specialization of the students, the support given by the teachers during the development of the project, the structure and organization of the semester, as well as the assessment moments and elements of the UC of Entrepreneurship.

Keywords: pedagogical innovation, entrepreneurship, interdisciplinary projects.

Ensino-aprendizagem de Empreendedorismo: Perceções de Estudantes Universitários

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Resumo

Consciente dos desafios da sociedade atual, a Universidade Portucalense (UPT) implementou uma unidade curricular (UC) integradora, designada de “Empreendedorismo”, transversal a todos os planos de estudos dos cursos de 1º ciclo da sua oferta formativa. Esta UC, inserida no 3º ano dos cursos de licenciatura, baseia-se numa metodologia de aprendizagem centrada em projetos, que decorre ao longo de 1 semestre, num total de 17 sessões, que podem assumir diferentes formatos pedagógicos: palestras, mentoria, seminários e *pitchs*. Os estudantes, de diferentes ciclos de estudos da UPT, constituem equipas de projeto, com quatro elementos no máximo. Cada equipa tem por objetivo desenvolver uma ideia de negócio inovadora e que demonstre ter viabilidade económica e financeira. Este estudo procura conhecer as perceções dos estudantes sobre a UC de Empreendedorismo e o seu papel na aprendizagem e desenvolvimento de competências dos estudantes. Para tal, no ano letivo de 2016/2017, foi aplicado um questionário aos estudantes (N=131). O questionário incluiu um conjunto de 40 questões, estruturadas segundo o modelo de escala de Likert, resultante de um quadro conceptual existente no domínio do PBL e de práticas de avaliação já desenvolvidas no contexto de Ensino Superior. O questionário aborda temas como as aprendizagens e competências desenvolvidas pelos estudantes, o trabalho em equipa, o papel do professor, o processo de avaliação dos estudantes e, de um modo geral, a avaliação do projeto como metodologia de Ensino e de aprendizagem. O questionário rentabilizado inclui, ainda, uma última questão sobre o carácter obrigatório ou opcional desta unidade curricular. Os resultados são discutidos, remetendo para implicações na intervenção pedagógica no Ensino Superior, sugerindo a necessidade de uma maior reflexão e discussão sobre a relevância e a natureza dos projetos para cada uma das diferentes áreas de especialidade dos estudantes, o apoio dado por parte dos docentes ao longo do desenvolvimento do projeto, a estrutura e organização do semestre, bem como dos momentos e elementos de avaliação da UC de Empreendedorismo.

Palavras-chave: inovação pedagógica, empreendedorismo, projetos interdisciplinares.

1 Introdução

Nos últimos anos, os autores da teoria sócio-cognitiva da carreira têm explicado a influência das experiências académicas nas Instituições de Ensino Superior em vários aspetos do desenvolvimento vocacional, enfatizando que as experiências académicas são fonte de informação relevante no processo de construção de significados, contribuindo para o desenvolvimento de interesses e valores vocacionais de estudantes do Ensino Superior (Costa-Lobo, 2011; Costa-Lobo e Ferreira, 2012; Magalhães et al., 2017). A transição para o mercado de trabalho é vista como um componente do desenvolvimento vocacional que é categorizado por um longo processo no tempo, que começa antes da conclusão dos cursos de graduação e que persiste até mesmo o início da atividade laboral (Lent, Taveira, & Costa -Lobo, 2012; Magalhães et al., 2017). A pesquisa realizada nos últimos oitenta anos sobre a questão da "transição escola-mercado de trabalho" enfatizou a importância de pensar-se a preparação do Ensino Superior para o trabalho numa perspetiva desenvolvimental (Brennan & Little, 2006; Fugate & Kinicki, 2008; Weible, 2009; Yorke & Knight, 2007; Zhao & Liden, 2011). A escassez de experiências de aprendizagem em contextos de trabalho no evoluir da frequência de percursos formativos no Ensino Superior torna, aos Estudantes do Ensino Superior, difícil entender como funciona o mercado de trabalho, o que se espera dos jovens num contexto profissional, quais as competências que é útil desenvolver, bem como aprender quais as competências que, sendo necessárias, são as mais valorizadas na sua área de especialização (Brennan & Little, 2006; Daniels & Brooker, 2014; Fugate & Kinicki, 2008; Jesus-Silva, Medeiros, Caramelo-Gomes, & Costa-Lobo, 2016; Weible, 2009).

Estes aspetos estão relacionados às dificuldades na transição para o mercado de trabalho, dificuldades reconhecidas tanto pelos empregadores quanto pelos jovens (Magalhães et al., 2017; Taveira et al., 2010, Weible, 2009; Yorke & Knight, 2007; Zhao & Liden, 2011). De acordo com Vieira e Marques (2014), as competências escolhidas pelos empregadores como as mais importantes para fins profissionais, nos primeiros cinco anos após a obtenção de graduação no Ensino Superior, são: análise e resolução de problemas, criatividade e inovação, adaptabilidade e flexibilidade, planificação e organização, motivação para a excelência.

Este artigo apresenta um estudo realizado na Universidade Portucalense (UPT), nomeadamente, no âmbito de uma unidade curricular, designada de "Empreendedorismo", transversal a todos os cursos de 1º ciclo UPT, que procura precisamente responder aos desafios da sociedade atual e das competências profissionais que os estudantes do século XXI devem possuir. Esta unidade curricular baseia-se numa metodologia de aprendizagem centrada em projetos, que decorre ao longo de um semestre, num total de 17 sessões, que podem assumir diferentes formatos pedagógicos: palestras, mentoria, seminários e *pitchs*. Os estudantes, de diferentes ciclos de estudos da UPT, constituem equipas de projeto, com o objetivo desenvolver uma ideia de negócio inovadora e que demonstre ter viabilidade económica e financeira. Este estudo procura identificar as perceções dos estudantes sobre esta unidade curricular, nomeadamente, sobre o seu papel na aprendizagem e no desenvolvimento de competências, o papel dos professores, o trabalho em equipa, o modelo de avaliação e, por último, a avaliação do projeto como metodologia de ensino-aprendizagem.

2 Contexto do Estudo

O estudo que apresentamos neste trabalho decorre no contexto da unidade curricular – Empreendedorismo - transversal a todos os 10 cursos do 1º ciclo de estudos da Universidade Portucalense Infante D. Henrique (UPT), instituição privada de ensino superior, certificada pela ISO 9001, reconhecida pelo Governo Português e pela Agência Portuguesa de Avaliação e Acreditação do Ensino Superior.

Trata-se de uma metodologia inovadora que decorre ao longo de 1 semestre, num total de 17 sessões, que podem assumir diferentes formatos pedagógicos: palestras, mentoria, seminários e pitchs. Os estudantes, de diferentes ciclos de estudos da UPT, tais como Psicologia, Educação Social, Turismo, Economia, Direito, Gestão, Informática, Gestão e Sistemas de Informação e Gestão da Hospitalidade, constituem equipas de projeto, com 4 elementos no máximo. As equipas de estudantes são constituídas de forma aleatória, sendo que é recomendado aos estudantes que incluam elementos de outros cursos no seu grupo. Cada equipa tem por objetivo desenvolver uma ideia de negócio inovadora e que demonstre ter viabilidade económica e financeira para concorrer com sucesso à incubadora da Net UPT (tabela 1). A equipa docente é constituída por 4 professores, todos pertencentes ao Departamento de Economia, Gestão e Informática (DEGI) da UPT. Cada um dos 4 docentes é responsável por assegurar o processo de mentoria a um conjunto de grupos, para além da sua colaboração na organização das palestras, seminários e *pitchs*. Relativamente ao tipo de abordagem de projeto, considerando a classificação apresentada por Helle, Tynjälä & Olkinuora (2006), considera-se que a UC de Empreendedorismo segue uma abordagem de "project component", tratando-se de um projeto de natureza essencialmente interdisciplinar, tendo em vista a resolução de problemas reais por parte de estudantes, promovendo assim a sua autonomia. A organização da unidade curricular está dividida em cinco momentos diferentes: (1) da ideia à oportunidade; (2) da oportunidade ao modelo de negócio; (3) do modelo de negócio ao plano de negócio; (4) do plano de negócio ao financiamento do negócio; (5) do financiamento do negócio à elaboração da candidatura à Net UPT (incubadora da UPT).

No que diz respeito aos resultados da aprendizagem dos alunos, espera-se que no final da unidade curricular de Empreendedorismo, os alunos sejam capazes de:

- Escolher um dos diferentes tipos de projetos de empreendedorismo: social, empresarial, cultural, educativo, urbano, rural, ecoturístico e intra-empreendedor;
- Identificar oportunidades de mercado e fontes de ideias inovadoras;
- Aplicar a metodologia Canvas para "desenhar" o modelo de negócio que demonstre a priori a viabilidade económico-financeira;

- Validar a viabilidade da ideia e do seu modelo de negócio escolhido;
- Elaborar e elaborar um plano de negócios;
- Preparar adequadamente e comunicar em três Pitch;
- Defender o plano de negócios com potenciais investidores;
- Decidir como financiar o projeto de negócios;
- Elaborar um projeto de candidatura à Net UPT.

Tabela 1: Organização da UC de Empreendedorismo – 1º semestre 2016/2017

Nº de sessões	Tipo	Objetivos	Duração
2	**Palestras**	Transmitir aos alunos uma perspetiva dos diferentes tipos de empreendedorismo e ensinar a metodologia do modelo de Canvas.	240 minutos (120 cada)
8	**Mentoria**	Processo de mentoria por parte dos docentes aos alunos, em termos do acompanhamento: (1) da ideia à oportunidade; (2) da oportunidade ao modelo de negócio; (3) do modelo de negócio ao plano de negócio; (4) do plano de negócios ao financiamento do negócio.	960 minutos (120 cada)
3	**Seminários**	(1) Jovens empreendedores relatam aos alunos as suas aventuras empresariais que levaram a cabo, apresentando alguns cuidados a levar em linha de conta na criação de um negócio; (2) Especialistas explicam como se deve levar a cabo um plano de negócio; e (3) Especialistas explicam como se deve preparar o plano de negócios.	270 minutos (90 cada)
3	***Pitch***	Os *pitchs* são um momento reflexão e de avaliação dos projetos apresentados por parte dos alunos perante um júri.	60 minutos (20 cada)
1	**Candidatura à Net UPT**	Apoio por parte dos docentes na elaboração do projeto de candidatura à Net UPT.	120 minutos
1	**Incubação**	Um júri procede à (5) avaliação da candidatura do projeto de empreendedorismo da equipa dos alunos que é submetido à Net UPT.	2 anos**

**(período de elaboração da candidatura 30 dias)

3 Metodologia

O estudo seguiu uma metodologia de natureza quantitativa, procurando verificar o grau de satisfação dos estudantes que participam nesta abordagem de projeto, que caracteriza a metodologia de ensino-aprendizagem da unidade curricular de Empreendedorismo.

Em primeiro lugar, contactou-se a Reitoria da Universidade Portucalense, durante o ano letivo de 2016/2017, com o intuito de solicitar a autorização para esta recolha de dados, e informar sobre os objetivos e o processo da recolha de dados. Após consentimento por parte da Reitoria, foram informados os docentes e os Estudantes da Unidade curricular acerca dos objetivos e pertinência deste estudo. A recolha de dados foi realizada em contexto de sala de aula, em circunstâncias previamente acordadas entre os investigadores e os professores. Os dados foram recolhidos no 1º semestre letivo do ano 2016/2017.

Para tal, no ano letivo de 2016/2017, foi aplicado um questionário aos estudantes (N=131). O *Questionário para Avaliação das Práticas Pedagógicas de Empreendedorismo* (QAPPE) incluiu um conjunto de 40 questões, estruturadas segundo o modelo de escala de Likert, resultante de um quadro conceptual existente no domínio do PBL (*Project-based Learning*) e de práticas de avaliação já desenvolvidas no contexto de Ensino Superior (Lima et al., 2017; Fernandes, et al., 2014; Alves et al., 2012). O questionário, adaptado e validado pelos autores deste trabalho, aborda temas como as aprendizagens e as competências desenvolvidas pelos estudantes, o trabalho em equipa, o papel do professor, o processo de avaliação dos estudantes e, de um modo geral, a avaliação do projeto como metodologia de Ensino e de aprendizagem. O questionário rentabilizado inclui, ainda, uma última questão sobre o carácter obrigatório ou opcional desta unidade curricular.

A amostra de participantes é do tipo não probabilística, constituída por conveniência, sendo composta por estudantes de sete ciclos de estudos conferentes do grau de licenciado, ciclos de estudo correspondentes à oferta do Departamento de Psicologia e Educação (n = 33, 25.1%), Departamento de Direito (n = 29, 22.1 %), Departamento de Turismo, Património e Cultura (n = 13, 9.92%) e à oferta do Departamento de Economia, Gestão e Informática (n = 56, 42.7%).

No grupo de participantes, 49 têm mais de três matrículas (37.4%) no Ensino Superior. A maioria dos participantes não tem experiência de estágio anterior (n = 97, 74.0%), não tem estatuto de estudante-trabalhador (n = 101, 77.0%) e não tem estatuto de estudante associativo (n = 93 , 70.9%).

Foi testada a possibilidade de realizar uma análise fatorial e posteriormente avaliar os dados psicométricos e a confiabilidade de cada dimensão, para testar a validade interna do QAPPE. Houve evidências da adequação da análise fatorial. Foi avaliada a variância explicada pela análise de componentes principais, definindo previamente a análise em seis fatores. Ao definir seis componentes principais, as dimensões explicaram mais de 67% da variabilidade total.

A análise da confiabilidade do tamanho e a avaliação da homogeneidade dos itens permitem obter valores de consistência interna muito elevados para todos os itens e para todas as dimensões.

A consistência interna do QAPPE, em termos globais, é de α =.87. Em relação às subescalas do QAPPPE, todas apresentaram elevada consistência interna, com os seguintes resultados de consistência interna: apreciação crítica do projeto, α = .86; aprendizagens e competências desenvolvidas, α =.92; trabalho em equipa, α =.81; papel do docente e papel do tutor, α =.92; avaliação do desempenho dos estudantes, α = .91; e eficácia do projeto como metodologia de Ensino-aprendizagem, α =.84.

Os valores encontrados foram adequados para manter a estrutura e a distribuição dos itens iniciais, assumindo o QAPPE seis dimensões: apreciação crítica do projeto, aprendizagens e competências desenvolvidas, trabalho em equipa, papel do docente e papel do tutor, avaliação do desempenho dos estudantes, e eficácia do projeto como metodologia de Ensino-aprendizagem. O QAPPE evidenciou bons níveis de validade e de confiabilidade.

4 Análise dos Resultados

A análise dos dados foi processada através do programa *IBM Statistical Package for the Social Science (SPSS)*, versão 23.0 para Windows. Para caraterização e descrição da amostra utilizaram-se estatísticas de frequência e descritivas de tendência central e dispersão (média e desvio-padrão), acrescentando-se a assimetria e a curtose para verificar violações à distribuição normal. Atendendo à dimensão da amostra (N=131) e o facto de quase todas as variáveis assumirem distribuição normal, optou-se pela realização de testes paramétricos, nomeadamente o *T-student* para amostras independentes para o estudo das diferenças e o teste de correlação de *Pearson* para o estudo de associações. Contudo, quando a análise englobava o número de inscrições no Ensino Superior, optou-se por testes não paramétricos, pelo facto desta variável ser ordinal, nomeadamente o teste de Mann-Whitney para o estudo das diferenças e o teste de correlação de *Spearman* para o estudo das associações. Para o estudo dos efeitos preditores da eficácia do projeto como metodologia de Ensino-aprendizagem recorreu-se ao teste de regressão linear múltipla. O nível mínimo de significância considerado foi de 95% (p<.05).

Na concretização do processo de análise dos dados houve interesse de sinalizar a sua distribuição no respeitante à apreciação crítica do projeto, no respeitante às aprendizagens e competências desenvolvidas, no concernente ao trabalho concretizado em equipa, no referente ao papel do professor, nos elementos relacionados com processo de avaliação dos estudantes e, igualmente, com a avaliação do projeto como metodologia de Ensino e de aprendizagem Tendo em conta os resultados estatisticamente significativos encontrados, e visando o estudo dos efeitos preditores de um conjunto de caraterísticas e variáveis nas aprendizagens e competências desenvolvidas, recorreu-se ao teste de regressão linear múltipla.

Ao analisar a distribuição dos resultados de acordo com a idade, é possível verificar que a média das respostas de todas as dimensões aumentou com o aumento da idade, demonstrando, em particular, que os estudantes com mais de 21 anos de idade possuem uma avaliação geral do projeto mais elevada do que os estudantes mais jovens.

No que respeita às dimensões representativas da apreciação crítica do projeto, houve diferenças estatisticamente significativas entre os sexos [t (128) = 3.06, p <001], com os rapazes a avaliarem mais positivamente o projeto (M = 2.8, DP = .11), quando comparados com as raparigas (M = 2.49, DP = .26).

Na categoria da apreciação crítica do projeto, a maior taxa de resposta é encontrada entre os estudantes com mais de 21 anos. Analisando os resultados de acordo com o número de inscrições no Ensino Superior, existem diferenças estatisticamente significativas entre estudantes com mais de três matrículas e os restantes, em relação à apreciação crítica do projeto[t (128) = 2.21, p <.05], sendo os estudantes com mais do que três inscrições (M = 2.40, DP = .09) a apresentarem níveis superiores aos demais (M = 2.21, DP = .11).

De acordo com a experiência de estágio anterior, há diferenças estatisticamente significativas na apreciação crítica do projeto [t (127) = 2.21 p <.05] entre estudantes com experiência de estágio e sem experiência de estágio, com estudantes com experiência em estágio (M = 2.36, DP =. 11) a apresentarem níveis mais elevados quando comparados aos estudantes sem experiência de estágio (M = 2.16, DP = .08).

De acordo com o estatuto do aluno, não há diferenças estatisticamente significativas entre as categorias criadas para esse fim. Foram sinalizadas diferenças estatisticamente significativas quanto à avaliação geral do projeto [t (127) = -2.16 p <.05, com estudantes que frequentam o ciclo de estudos de Gestão (M = 3.33, DP = .19) em comparação com aqueles que não frequentam este ciclo de estudos (M = 3.02, DP = .18).

4.1 Aprendizagens e competências desenvolvidas

Analisando os resultados de acordo com o número de inscrições no Ensino Superior, existem diferenças estatisticamente significativas entre estudantes com mais de três matrículas e os restantes, em relação às aprendizagens e competências desenvolvidas [t (121) = 2.46 p <.05], sendo os estudantes com mais do que três inscrições (M = 2.54, DP = .06) a apresentarem níveis superiores aos demais (M = 2.07, DP = .05). De acordo com a experiência de estágio anterior, há diferenças estatisticamente significativas nas aprendizagens e competências desenvolvidas [t (120) = 2.21 p <.05] entre estudantes com experiência de estágio e sem experiência de estágio, com estudantes com experiência em estágio (M = 2.36, DP =. 11) a apresentarem níveis mais elevados quando comparados aos estudantes sem experiência de estágio (M = 2.16, DP = .08). De acordo com o estatuto do aluno, não há diferenças estatisticamente significativas entre as categorias criadas para esse fim. Não foram sinalizadas diferenças estatisticamente significativas quanto às aprendizagens e competências desenvolvidas [t (120) = -2,01, p <.05, com estudantes que frequentam o ciclo de estudos de Gestão (M = 3.33, DP = .08) em comparação com aqueles que não frequentam este ciclo de estudos (M = 3.29, DP = .06).

4.2 Trabalho em equipa

Analisando os resultados de acordo com o número de inscrições no Ensino Superior, existem diferenças estatisticamente significativas entre estudantes com mais de três matrículas e os restantes, em relação ao trabalho em equipa [t (121) = 2.46 p <.05], sendo os estudantes com mais do que três inscrições (M = 2.54, DP = .06) a apresentarem níveis superiores aos demais (M =2.07, DP =.05). De acordo com a experiência de estágio anterior, há diferenças estatisticamente significativas no trabalho em equipa [t (120) =2.87 p <.05] entre estudantes com experiência de estágio e sem experiência de estágio, com estudantes com experiência em estágio (M = 3.78, DP =. 12) a apresentarem níveis mais elevados quando comparados aos estudantes sem experiência de estágio (M = 2.10, DP =.02). De acordo com o estatuto do aluno. há diferenças estatisticamente significativas no trabalho em equipa [t (120) = 2.99 p <.05] entre estudantes com experiência de estágio e sem experiência de estágio, com estudantes com experiência em estágio (M = 3.99, DP =.12) a apresentarem níveis mais elevados quando comparados aos estudantes sem experiência de estágio (M = 2.05, DP = .02).

4.3 Papel do docente e papel do tutor

Analisando os resultados de acordo com o número de inscrições no Ensino Superior, não existem diferenças estatisticamente significativas entre estudantes com mais de três matrículas e os restantes, em relação ao papel do docente e papel do tutor [*t* (121) = 2.98 *p* <.05]. De acordo com a experiência de estágio anterior, há diferenças estatisticamente significativas na avaliação do papel do docente e papel do tutor [*t* (120) = 2.87 *p* <.05] entre estudantes com experiência de estágio e sem experiência de estágio, com estudantes com experiência em estágio (*M* = 3.98, *DP* =.12) a apresentarem níveis mais elevados quando comparados aos estudantes sem experiência de estágio (*M* = 2.46, *DP* = .02). De acordo com o estatuto do aluno, há diferenças estatisticamente significativas na avaliação do papel do docente e papel do tutor [*t* (120) = 3.81 *p* <*.05*] entre estudantes com experiência de estágio e sem experiência de estágio, com estudantes com experiência em estágio (*M* = 4.21, *DP* =.19) a apresentarem níveis mais elevados quando comparados aos estudantes sem experiência de estágio (*M* = 3.69, *DP* = .18).

4.4 Avaliação do desempenho dos estudantes

Analisando os resultados de acordo com o número de inscrições no Ensino Superior, não existem diferenças estatisticamente significativas entre estudantes com mais de três matrículas e os restantes, em relação à avaliação do desempenho dos estudantes [*t* (121) = 3.78 *p* <.05]. De acordo com a experiência de estágio anterior, há diferenças estatisticamente significativas na avaliação do desempenho dos estudantes [*t* (120) = 3.26 *p* <.05] entre estudantes com experiência de estágio e sem experiência de estágio, com estudantes com experiência em estágio (*M* = 3.97, *DP* =.12) a apresentarem níveis mais elevados quando comparados aos estudantes sem experiência de estágio (*M* = 2.10, *DP* =.02). De acordo com o estatuto do aluno, não há diferenças estatisticamente significativas no trabalho em equipa [*t* (120) = 3.52 *p* <*.05*] entre estudantes com experiência de estágio e sem experiência de estágio.

4.5 Eficácia do projeto como metodologia de Ensino-aprendizagem

No que respeita às dimensões representativas da eficácia de projeto como metodologia de Ensino-aprendizagem, houve diferenças estatisticamente significativas entre os sexos [*t* (128) = 3.28, *p* <.001], com os rapazes a avaliarem mais positivamente a eficácia de projeto como metodologia de Ensino-aprendizagem (*M* = 3.91, *DP* = .11), quando comparados com as raparigas (*M* = 2.34, *DP* = .14).

Na categoria da eficácia de projeto como metodologia de Ensino-aprendizagem,, a maior taxa de resposta é encontrada entre os estudantes com mais de 21 anos. Analisando os resultados de acordo com o número de inscrições no Ensino Superior, existem diferenças estatisticamente significativas entre estudantes com mais de três matrículas e os restantes, em relação à apreciação crítica do projeto[*t* (128) = 3.41, *p* <.05], sendo os estudantes com mais do que três inscrições (*M* = 3.99, *DP* = .09) a apresentarem níveis superiores aos demais (*M* = 3.22, *DP* = .04).

De acordo com a experiência de estágio anterior, há diferenças estatisticamente significativas na eficácia de projeto como metodologia de Ensino-aprendizagem [*t* (127) = 2.41 *p* <*.05*] entre estudantes com experiência de estágio e sem experiência de estágio, com estudantes com experiência em estágio (*M* = 2.36, *DP* =.11) a apresentarem níveis mais elevados quando comparados aos estudantes sem experiência de estágio (*M* = 2.09, *DP* = .08).

De acordo com o estatuto do aluno, não há diferenças estatisticamente significativas entre as categorias criadas para esse fim.

Foram sinalizadas diferenças estatisticamente significativas quanto à eficácia de projeto como metodologia de Ensino-aprendizagem [t (127) = -2.16 p <.05, com estudantes que frequentam o Departamento de Psicologia e Educação (*M* = 3.33, *DP* = .19) em comparação com aqueles que não frequentam os ciclos de estudos oferecidos por este Departamento (*M* = 3.02, *DP* = .18).

4.6 Predição das aprendizagens e competências desenvolvidas

Tendo em conta os resultados estatisticamente significativos encontrados até ao momento, decidiu estudar-se os efeitos preditores de um conjunto de caraterísticas e variáveis nas aprendizagens e competências desenvolvidas, recorrendo-se para o efeito, ao teste de regressão linear múltipla.

No modelo inicial foram introduzidos os preditores frequência prévia de estágio, papel do docente e papel do tutor, número de matrículas no Ensino Superior, trabalho em equipa, eficácia do projeto como metodologia de Ensino-aprendizagem, ciclo de estudos frequentado e departamento em que se inscreve o ciclo de estudos frequentado, tendo sido constatado que estas variáveis em conjunto explicam 26.4% da variância nas aprendizagens e competências desenvolvidas (R^2=.264; F=8.899; p<.001). Analisando a influência de cada variável verificou-se que só as variáveis avaliação do desempenho dos estudantes, trabalho em equipa, eficácia do projeto como metodologia de Ensino-aprendizagem, e apreciação crítica do projeto se revelam estatisticamente significativas, pelo que se construiu um novo modelo preditivo, patente na figura 1, incluindo também o papel do docente e papel do tutor, variável cujos valores se tinham revelado marginalmente significativos. Neste sentido, observa-se que estas variáveis explicam em conjunto 24.9% da variância nas aprendizagens e competências desenvolvidas, melhorando o modelo preditivo (R^2=.249; F=13.359; p<.001).

Neste modelo verifica-se que as aprendizagens e competências desenvolvidas são influenciadas positivamente pelas seguintes variáveis: papel do docente e papel do tutor, em que atribuir pontuações elevadas ao papel do docente e papel do tutor, aumenta .178 pontos da média nas aprendizagens e competências desenvolvidas (β=.178; p<.01); trabalho em equipa, em que cada grau que aumenta a pontuação do trabalho em equipa, aumenta .205 pontos da média nas aprendizagens e competências desenvolvidas (β=.205; p<.01); eficácia do projeto como metodologia de Ensino-aprendizagem, em que cada ponto que melhora a avaliação da eficácia do projeto em termos metodológicos, aumenta .200 pontos da média nas aprendizagens e competências desenvolvidas (β=.200; p<.01); e apreciação crítica do projeto, em que cada ponto que aumenta a apreciação crítica do projeto, aumenta .269 pontos da média nas aprendizagens e competências desenvolvidas (β=.269; p<.001). Por outro lado, destaca-se que a avaliação do desempenho dos estudantes influencia negativamente nas aprendizagens e competências desenvolvidas, sendo que níveis elevados na avaliação do desempenho dos estudantes diminui em média .222 pontos da média das aprendizagens e competências desenvolvidas (β=-.222; p<.001).

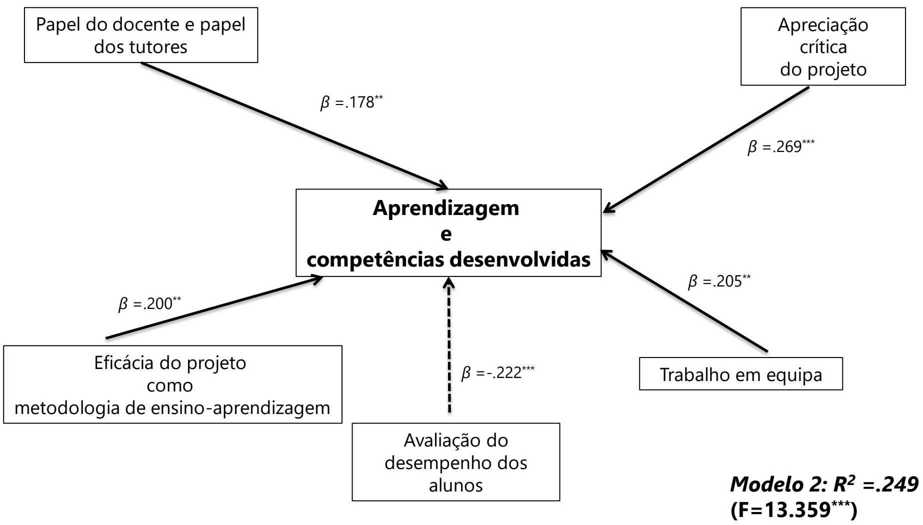

Figura 1. Esquema integrativo dos resultados preditores das aprendizagens e competências desenvolvidas.

(β: Coeficiente Estandardizado; R^2: Valor da Regressão – Variância Explicada; F: Tamanho do Efeito do Teste ANOVA; Níveis de Significância: *p<,05; **p<,01; ***p<,001; ^{a}p < .07 (marginalmente significativo)).

5 Conclusões

De um modo geral, os resultados permitem concluir que os estudantes avaliam de forma positiva a unidade curricular de *Empreendedorismo*, embora seja importante destacar um conjunto de aspetos que carecem de uma maior reflexão e discussão, nomeadamente, no que se refere à relevância dos projetos para cada uma das diferentes áreas de especialidade dos estudantes, o apoio dado por parte dos docentes ao longo do desenvolvimento do projeto, a estrutura e organização do semestre, bem como os momentos e elementos de avaliação da UC de Empreendedorismo. Estas implicações têm impacto ao nível da intervenção pedagógica no Ensino Superior, que se pretende que esteja cada vez mais alinhada com ambientes de aprendizagem significativos e inovadores. Os resultados explanam que as aprendizagens e competências desenvolvidas pelos estudantes são influenciadas positivamente pelo papel do docente e papel do tutor, pelo trabalho em equipa, pela eficácia do projeto como metodologia de Ensino-aprendizagem, e pela apreciação crítica do projeto. Os resultados obtidos sugerem a necessidade de, visando assegurar níveis elevados das aprendizagens e das competências desenvolvidas pelos estudantes, vigiar-se a existência de níveis elevados de percepção do papel do docente e papel do tutor, confirmar a qualidade do trabalho feito em equipa, garantir a eficácia do projeto como metodologia de Ensino-aprendizagem, e garantir níveis elevados de apreciação crítica do projeto por parte dos estudantes implicados nesta metodologia.

Com este trabalho, na sequência de um conjunto dilatado de trabalhos de co-autoria dos autores (e.g., Costa-Lobo, 2011) reforça-se a relevância da formação de docentes do Ensino Superior em aprendizagem baseada em projetos, destacando-se a pertinência de sistematizar o papel do docente e o papel dos tutores que permitam aprender em contextos de grupo, que potenciem a resolução de problemas e a tomada de decisões, além de promover o trabalho em equipa.

Este artigo, seguindo o trabalho de Magalhães et al. (2017) apresenta informações que reforçam que é importante, para desenvolver as aprendizagens e as competências desenvolvidas pelos estudantes do Ensino Superior, considerar as seguintes sugestões e estratégias de intervenção: clarificar as responsabilidades do docente, clarificar o papel dos tutores, investir na conceção de projetos com significado para os estudantes, concretizar cenários de rentabilização de aprendizagem baseada em projetos que potenciem a antecipação das circunstâncias de avaliação, com conhecimento partilhado, por estudantes e avaliadores, dos critérios de avaliação. Este trabalho vem contribuir para destacar a importância de aumentar-se o nível de experiências práticas oferecidas aos estudantes do Ensino Superior durante o seu percurso académico, investir-se na criação de cenários pedagógicos com a finalidade de orientação, *mentoring*, *coaching* e desenvolvimento de talentos dentro e fora do sistema educacional.

Este trabalho reforça a importância das Instituições de Ensino Superior oferecerem oportunidades para a simulação e experimentação de papéis laborais, prepararem os Estudantes para resolver problemas usais e rotineiros em cenários laborais, permitirem o treino em técnicas de gestão de carreira.

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Minicentral Hidreletrica applied to the development of an interdisciplinary project of the Course of Production Engineering

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Abstract

Engineering education is increasingly associated with practical applications for development in the entire process of student learning. The Interdisciplinary Project has as general objective the application of the knowledge acquired in situations or theoretical-practical problems, selected in such a way as to allow the integration between the disciplines and the deepening of the students' socialization, the contextualization of the knowledge acquired in the classroom, punctuality and skill development. It is applied to the Production Engineering Course of UNISAL in Lorena (SP / Brazil), specifically to the group of the 4th semester of the current year, the construction of a micro hydroelectric plant, which should use some engineering concepts, such as: transport phenomena, general mechanics, physics, calculus, etc. Basically a mini-hydroelectric plant consists of the following parts: Dam; Water collection and adduction systems; Powerhouse; System of restitution of water to the natural bed of the river. Each part consists of a set of works and facilities harmoniously designed to operate, efficiently, together. With this project, students will be encouraged to develop knowledge about energy forms and energy transformation in a hydroelectric plant and the equipment involved in this process. Many theoretical concepts will be confirmed in practice: kinetic and potential energy, velocity, flow, pressure, hydraulic power, mechanical power, efficiency, turbines, pumps, sluices, magnets, electromagnetic induction, electricity, among others.

Keywords: Interdisciplinary Project; Mini Hydropower Plant; Industrial Engineering; Basic Training.

Minicentral Hidrelétrica aplicada ao desenvolvimento de um projeto interdisciplinar do curso de Engenharia de Produção

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Resumo

A educação em Engenharia cada vez mais está associada a aplicações práticas para o desenvolvimento por completo no processo de aprendizagem do aluno. O Projeto Interdisciplinar tem como objetivo geral a aplicação dos conhecimentos adquiridos em situações ou problemas teórico-práticos, selecionado de maneira a permitir a integração entre as disciplinas e o aprofundamento da socialização dos alunos, a contextualização dos conhecimentos adquiridos em sala de aula, organização, pontualidade e o desenvolvimento de habilidades. Aplica-se ao Curso de Engenharia de Produção do UNISAL em Lorena (SP/Brasil), especificamente à turma do 4º semestre letivo do presente ano, o projeto da construção de uma micro central hidrelétrica, que deverá utilizar alguns conceitos da engenharia, tais como: fenômenos de transporte, mecânica geral, física, cálculo, etc. Basicamente, uma minicentral hidrelétrica compõe-se das seguintes partes: Barragem; Sistemas de captação e adução de água; Casa de força; Sistema de restituição de água ao leito natural do rio. Cada parte se constitui em um conjunto de obras e instalações projetadas harmoniosamente para operar, com eficiência, em conjunto. Com este projeto, os alunos serão estimulados a desenvolver o conhecimento sobre as formas de energia e a transformação de energia em uma hidrelétrica e os equipamentos envolvidos nesse processo. Muitos conceitos teóricos serão confirmados na prática: energia cinética e potencial, velocidade, vazão, pressão, potência hidráulica, potência mecânica, rendimento, turbinas, bombas, comportas, imãs, indução eletromagnética, eletricidade, entre outros.

Palavras-Chave: Projeto Interdisciplinar; Minicentral Hidrelétrica; Engenharia de Produção; Formação Básica.

1 Introdução

Segundo Gemignani (2012) o professor tem um papel importante, que é permitir que o estudante aprimore e melhore a visão de forma independente e autônoma, pois requer um esforço para ambos no sentido de verificar modelos e cenários de ensino. Ainda segundo o autor, o aprendizado por projetos caracteriza-se pela busca de informações sobre o problema escolhido com alguns componentes que são fundamentais para o sucesso de aprendizagem como uma sistematização da metodologia com algumas etapas, como as seguintes: observação da realidade; pontos chaves; teorização; hipóteses de solução; aplicação à realidade. Estas etapas são apenas um caminho no qual é articulado à participação individual e em grupo, sendo assim, uma equipe desenvolve a capacidade de acompanhar, mediar, analisar, verificar as necessidades, resultados e lacunas nos projetos em se que envolvem.

Para Crawley *et al*.. (2007), os objetivos para os cursos de graduação em Engenharia, tem as seguintes propriedades:

- Ter a prática moderna da engenharia de modo que as intenções do objetivo fluam naturalmente nos papéis reais da profissão dos engenheiros;
- Ser abrangente o suficiente de modo desenvolvendo ao máximo as práticas na educação em engenharia;
- Ser completo e consistente, na medida em que todos os conhecimentos, habilidades e atitudes esperados para a graduação do engenheiro estejam incluídos;
- Ser apresentado de forma suficientemente detalhada em que os tópicos específicos possam ensinados e aprendidos, estabelecendo as bases para o planejamento do currículo e avaliação baseada em resultados;

- Ser ligado a um processo de pesquisa que estabelecerá níveis de proficiência amplamente acordados que seria esperado de um engenheiro graduado;
- Expressar por meio de uma linguagem específica e formal, os objetivos de aprendizagem, o que deverá conduzir a uma interpretação coerente e avaliável do nível desejado de proficiência.

O objetivo deste artigo é a apresentar uma abordagem de um gerenciamento de projeto para promover as habilidades do aluno no processo de resolução de problemas reais através do trabalho em equipe que, com o conhecimento multidisciplinar, identificar as principais características de um projeto de minicentral Hidrelétrica e estabelecer a ponte entre contribuições teóricas e sua prática cotidiana.

2 Projetos interdisciplinares

Para Bonatto *et al.* (2012), a interdisciplinaridade é um elo entre o entendimento das disciplinas nas suas diversas áreas. Sua importância está relacionada ao fato da possibilidade de abranger temáticas e conteúdo, permitindo dessa forma recursos inovadores e dinâmicos, em que as aprendizagens são ampliadas.

A interdisciplinaridade surgiu nos anos 70 como resposta às necessidades de uma abordagem mais integradora da realidade. Ainda que muitas vezes esteja associada à modismo ou à realização de projetos apenas aparentemente ou pseudo-interdisciplinares na área da educação, ela nasce da hipótese de que, por seu intermédio, é possível superar os problemas decorrentes da excessiva especialização, contribuindo para vincular o conhecimento à prática segundo Dencker (2002).

Segundo Tavares (1999) o caminho interdisciplinar é amplo no seu contexto e revela um quadro que precisa ser redefinido e ampliado. Tal constatação induz a reflexão sobre a necessidade de professores e alunos trabalharem unidos, se conhecerem e se entrosarem para juntos vivenciarem uma ação educativa mais produtiva. O papel do professor é fundamental no avanço construtivo do aluno. É a partir dele que o professor pode captar as necessidades do aluno e o que a educação lhe proporcionar. A interdisciplinaridade do professor pode envolver e modificar o aluno quando ele assim o permitir.

De acordo com Powell e Weenk (2003), cada projeto é geralmente apoiado por diversas disciplinas teóricas ligadas por um tema que qualifica a unidade do currículo. Uma equipe de estudantes discute o problema, fornece uma solução e entrega em um tempo determinado um produto da equipe tal como um protótipo e um relatório da equipe. E quando se trata de cursos de Engenharia, essa necessidade fica ainda mais evidente. Assim, associar projetos ao conteúdo das disciplinas passa a ser um desafio para professores e alunos, principalmente integrando a grade curricular, resultando nos projetos interdisciplinares.

Com a adoção desta metodologia, Lima *et al.* (2007) descrevem que os alunos desenvolvem diversas competências relacionadas a: Conhecimento, Habilidades e Atitudes. Aprendizagem baseada em projetos usa problemas do mundo real para motivar os alunos a identificar e aplicar conceitos das disciplinas curriculares e informações do processo de pesquisa.

Diante deste desenvolvimento inovador de ensino, Cajander *et al.* (2011) descrevem que o processo de aprendizagem se tornou interdisciplinar e a avaliação das competências profissionais nos estudantes de engenharia passou a ser fundamental.

2.1 Competências do Engenheiro de Produção

Embora não exista um acordo unânime sobre o significado de "competência", muitos autores definem isso como a capacidade de executar tarefas efetivamente especificadas. Ou seja, as competências são consideradas, nesta perspectiva, como habilidades relacionadas ao desempenho profissional.

O campo de atuação da Engenharia de Produção, segundo a ABEPRO (Associação Brasileira de Engenharia de Produção) é muito vasto, sendo necessário destacar que compete ao egresso do curso, o projeto, a implantação, a operação, a melhoria e a manutenção de sistemas produtivos integrados de bens e serviços, envolvendo homens, materiais, tecnologia, informação e energia. Compete ainda especificar, prever e avaliar os resultados obtidos destes sistemas para a sociedade e o meio ambiente, recorrendo a conhecimentos especializados da matemática, física, ciências humanas e sociais, conjuntamente com os princípios e métodos de análise e projeto da engenharia. (ABEPRO, 2001).

Shuman *et al.* (2005), expressam claramente que as habilidades profissionais podem ser ensinadas e avaliadas, embora o "ensino" possa não ser a abordagem mais adequada para usar neste contexto. O "desenvolvimento" também pode ser usado para enfatizar a natureza centrada no aluno do processo de aprendizagem de habilidades profissionais.

O desenvolvimento das competências profissionais está estritamente relacionado com a sua avaliação, uma vez que os mecanismos de avaliação podem ser utilizados como uma ferramenta de aprendizagem. Em um projeto, as competências técnicas e profissionais estão entrelaçadas, não só no que diz respeito ao seu desenvolvimento, mas também no processo de avaliação. A avaliação de um relatório técnico envolve o conteúdo técnico, bem como sua forma, sua estrutura e outras características que não estão diretamente relacionadas ao conteúdo técnico, sendo insuficiente para uma avaliação global (VAN HATTUM-JANSSEN e MESQUITA, 2011).

3 Aplicação de Projeto

Uma proposta de aprendizado baseado em problemas (PBL) vem sendo aplicada aos alunos do quarto semestre do curso de Engenharia de Produção do Centro Universitário Salesiano de São Paulo (UNISAL, campus São Joaquim) localizada em Lorena/SP. Um tema diferente é proposto semestralmente e envolve a interdisciplinaridade entre as disciplinas do semestre, sendo que o resultado do projeto é apresentado ao fim do semestre.

Com o desenvolvimento das atividades no laboratório, a elaboração de uma sequência finita de etapas promove o controle de pessoal, analisam-se tempo e custos em cada fase do projeto. A disciplina trabalha as habilidades de:

- Identificar, formular e resolver um problema proposto;
- Compreensão de sua responsabilidade no sucesso do objetivo proposto;
- Comunicação e expressão;
- Reconhecer que, na área da engenharia, é essencial a criatividade na resolução de novos problemas.

Desde 2016, o projeto interdisciplinar foi incluindo como componente curricular nos cursos de Engenharia da instituição estudada. O professor atribuído a esta disciplina tem a responsabilidade de transmitir conhecimentos gerais sobre projeto e seu gerenciamento, tais como:

- Definições e processos de um projeto de construção de uma Micro Central Hidrelétrica;
- Organização do projeto;
- Definição do escopo do projeto e seus objetivos;
- Construção da lista de atividades;
- Desenvolvimento de estimativas;
- Definição de dependências das atividades;
- Desenvolvimento de cronogramas realistas;
- Desenvolvimento de orçamento e controle de custos;
- Aspectos humanos e de comportamento de equipes;
- Determinação das regras e responsabilidades;
- Métodos de avaliação e acompanhamento do projeto;
- Fechamento e conclusão do projeto.

Para a realização deste projeto, a turma foi dividida em equipes com no máximo dez alunos. O primeiro passo, após apresentação do projeto e das partes constituintes de uma Minicentral Hidrelétrica, foi constituído da elaboração do planejamento do projeto, no qual foram utilizadas as ferramentas 5W2H e diagrama de *Gantt*. Tais ferramentas visam aprimorar conceitos de gestão de projetos, planejamento e controle.
No decorrer do semestre, o aluno torna-se o principal agente de seu aprendizado, pois é de sua responsabilidade elaborar uma pesquisa profunda sobre o assunto, desenvolver um protótipo, calcular e

explicar o fenômeno que está ocorrendo. Durante os encontros semanais entre professor e alunos, são realizadas reuniões de *check point* para a verificação do andamento do projeto.

3.1 Contribuição das disciplinas do Semestre

Foi proposto a construção de uma Minicentral Hidrelétrica, visando possibilitar aos alunos experimentar os conhecimentos teóricos e práticos do projeto. O Quadro 1 apresenta a matriz de contribuição das disciplinas incluídas neste projeto.

Disciplina	***Contribuição***
Fenômenos de Transporte	Transporte de energia e massa. Estática dos fluidos, hidrodinâmica, máquinas de fluxo. Transferência de calor e termodinâmica.
Cálculo Integral e Diferencial IV	Equações diferenciais de 1ª ordem: separáveis, exatas e lineares. Sistemas de Equações Diferenciais Ordinárias lineares. Aplicações. Equações diferenciais de 2a ordem.
Metodologia de Pesquisa Científica	Natureza da ciência e da pesquisa científica, modalidades de pesquisa, construção do projeto científico, modelo de projeto de pesquisa, normas e formatação.
Mecânica Geral	Estática das partículas e dos corpos rígidos no plano e no espaço.
Física IV	Indutância e circuitos RLC, Circuitos de corrente alternada. Circuitos em corrente continua.
WAC – *Writing Across Curriculum*	Apoio a elaboração dos relatórios pertinentes ao projeto, em suas diversas fases, como uma oportunidade de aprendizado através da escrita destes.

Quadro 1. Matriz de contribuição das disciplinas do 4o semestre da Engenharia de Produção

3.2 Sistema de Avaliação

Três apresentações e dois relatórios sendo um parcial e um final (em forma de artigo), em uma escala de 0 (zero) a 10 (dez).

MF = (0,1*Gate1) + (0,1*Gate2) + (0,1*Gate3) + (0,7*Gate4)

Onde:

- Gate 1 – Nota da primeira apresentação – período em agosto. Esta avaliação será aplicada a uma forma de apresentação oral realizada em grupo, sendo que serão avaliados os conceitos abordados e habilidade de argumentação do tema para cada aluno do grupo.
- Gate 2 – Nota de apresentação do relatório parcial – período em setembro. Para esta avaliação será feita a análise do relatório parcial que deve conter as informações sobre o desenvolvimento do projeto. Esta análise tem como objetivo básico, a orientação sobre a organização e a estruturação das informações contidas no relatório.
- Gate 3 – Nota da segunda apresentação – período em novembro. Esta avaliação será aplicada sobre a forma de apresentação realizada por um representante do grupo, sendo que este deve ter domínio dos conceitos abordados e habilidade de argumentação do tema, bem como a utilização de recursos multimídias.
- Gate 4 – Nota da apresentação final (50%) e entrega de artigo (20%) – período em novembro

Na apresentação final serão avaliados os critérios de arguição:

- Capacidade de comunicação com uma postura adequada,
- Demonstrar clareza na exposição dos conceitos, comunicar eficazmente.
- Revelar a capacidade de argumentação e problematização;
- Uso de recursos gráficos de exibição e animação em 3D;

- Criatividade, ou seja, apresenta ideias inovadoras, demonstrar originalidade e revela espírito de iniciativa.

E, os critérios técnicos:

- Protótipo montado conforme regras pré-estabelecidas;
- Protótipo operando dentro das características do projeto (funcionando);
- Potência gerada;
- Inovações apresentadas;
- Eficiência mecânica e energética do protótipo;

No artigo, serão avaliados os seguintes critérios:

- Adequação do trabalho aos objetivos propostos;
- Título, Autores, Introdução, Referencial Teórico (mínimo 1 página), Desenvolvimento, Conclusão e Referências;
- Formatação: Escrito em MS Word, espaçamento simples, justificado, fonte Calibri, tamanho 10, 6 à 8 páginas (incluindo referencial e anexos);
- Descrever o que foi apresentado nos GATES: materiais e equipamentos, investimentos, custos, controle, fluxograma, fotos e figuras.

4 Considerações Finais

Ao final do semestre espera-se que o aluno tenha desenvolvido habilidades relacionadas a resolução de problemas, capacidade de argumentação e problematização, trabalho em equipe e de apresentação oral e escrita, além de ter aliado o conhecimento prático com as disciplinas conteudistas lecionadas.

A prática do projeto interdisciplinar propõe ao aluno de Engenharia de Produção o desenvolvimento das competências preconizadas pela ABEPRO diante de um mercado cada vez mais exigente na qual o egresso do curso deva estar preparado para realizar as atividades profissionais.

Quanto a minicentral hidrelétrica, ela potencializa os conceitos importantes no processo de formação básica da Engenharia, relacionados ao raciocínio lógico, do pensamento sistêmico e, principalmente, na capacidade de resolução de problemas. Isso difere o engenheiro das demais profissões.

Como indicação de trabalhos futuros pode-se avaliar os estudantes diante da expectativa e percepção quanto ao real desenvolvimento das competências propostas ao projeto.

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Bridge of toothpicks as an interdisciplinary project applied to the teaching of Industrial Engineering

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Abstract

The discipline interdisciplinary project is common to the training of graduates of engineering courses. It is important the development in the future engineers the interest for the construction of resistant bridges including concepts of resistance and selection of materials. The project is aligned with the objectives of the course and the intended profile of the egress especially in terms of skills: acting in a multidisciplinary way in research, planning, development and construction of a bridge of sticks. It is also important, for the graduation of Engineering courses, the development of skills such as: team interaction, equal distribution of tasks, etc., elaboration of technical reports and compliance with deadlines. The General Objective of this project was to enable students to experience the theoretical knowledge of the theory of structures and mechanics, regarding static. The construction used only popsicle sticks and white glue. The bridge should be constructed in such a way that it can be supported by supports that are 1 (one) meter apart (go between the supports). In the evaluation criterion will be considered the relation between the maximum load supported and the weight of the structure. With the elaboration and execution of this project, students will be encouraged to think about innovation, promoting the calculations to make feasible the project in small, medium and large scale, considering the physical phenomena involved, developing design and production models, analyzing the technical and evaluating the feasibility of the project, considering the economic, social and environmental aspects. The specific objectives are: to appropriate the physical knowledge necessary for the construction of the bridge; define the characteristics of the materials required to meet project requirements; make a preliminary costing, aiming at the smallest budget in which it will be part of the final report; perform calculations / simulation for assembly and operation of the project.

Keywords: Active Learning, Education, Interdisciplinary Project, Bridge of Sticks.

Ponte de palitos como projeto interdisciplinar aplicado ao ensino de Engenharia de Produção

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Resumo

A disciplina projeto interdisciplinar é comum à formação dos egressos dos cursos de engenharias. É importante o desenvolvimento nos futuros engenheiros o interesse pela construção de pontes resistentes incluindo conceitos de resistência e seleção de materiais. O projeto alinha-se aos objetivos do curso e ao perfil pretendido do egresso em especial quanto às competências: atuação, de forma multidisciplinar, na pesquisa, no planejamento, no desenvolvimento e construção de uma ponte de palitos. É importante, ainda, para o egresso dos cursos de Engenharia, o desenvolvimento das capacidades tais como: interação em equipe, distribuição igualitária de tarefas, etc., elaboração de relatórios técnicos e cumprimento de prazos. O Objetivo Geral deste projeto foi possibilitar os alunos experimentar os conhecimentos teóricos da teoria de estruturas e mecânica, no tocante à estática. A construção utilizou apenas de palitos de picolé e cola branca. A ponte deverá ser construída de tal forma a permitir ser sustentada em apoios distantes de 1 (um) metro (vão entre os apoios). No critério avaliação será considerado a relação entre a máxima carga suportada e o peso da estrutura. Com a elaboração e execução deste projeto, os alunos serão instigados a pensar em inovação, promovendo os cálculos para viabilizar o projeto em pequena, média e larga escala, considerando os fenômenos físicos envolvidos, desenvolvendo modelos de projeto e produção, analisando as questões técnicas e avaliando a viabilidade do projeto, considerando os aspectos econômicos, sociais e ambientais. Os objetivos específicos são: apropriar-se dos conhecimentos físicos necessários para a construção da ponte; definir as características das matérias necessárias para atendimento dos requisitos do projeto; fazer um levantamento prévio dos custos, visando o menor orçamento na qual fará parte do relatório final; realizar cálculos/simulação para montagem e operação do projeto.

Palavras-Chave: Metodologia Ativa, Educação, Projeto Interdisciplinar, Ponte de Palitos.

1 Introdução

A ciência de forma geral historicamente falando teve um "divisor de águas", antes e pós Galileu, antes desse destacado cientista a ciência era descritiva e analítica, depois do advento da "torre de Pisa" a ciência passou a ser experimental, neste sentido deveria ser comprovada por meio testes e práticas, pode-se dizer que Galileu Galilei foi o "pai do experimento". Desde essa época os praticantes da ciência vêm utilizando da prática como comprovação.

O ser humano desde sua subsistência sempre precisou da prática como forma de aprendizagem, a teoria sem a "mão na massa" pode ser dificultosa a implementação de conceitos e conteúdos. Apesar de poder existir três situações de aprendizagem intuitivas e inerentes para cada pessoa, tais como, auditiva, visual e sinestésica. O termo "colocar a mão para fazer" pode se relacionar à sinestesia, principalmente para com o ensino da ciência e desenvolvimento tecnológico.

Segundo Mesquita *et al* (2009), descreve em seu trabalho que haveria um aumento da demanda por engenheiros que trabalham de forma integrada e com interdisciplinaridade e que seja por meio de times. Segundo os autores os alunos devem desenvolver competências relacionadas à trabalhos em equipes, tais como, comunicação interpessoal, gerenciamento de conflitos, autonomia, gestão do tempo e liderança. A educação baseada em abordagens de projetos pode auxiliar no desenvolvimento dessas competências. Ainda segundo os autores os estudantes teriam de usar toda aprendizagem de forma ativa dentro de um grupo ou time de trabalhos.

Para Lima *et al* (2009), a interação com as indústrias pode ajudar na aprendizagem, já que seriam baseadas por meio de projetos, neste sentido pode ajudar na qualidade do ensino onde o alvo seria a inovação, já que os projetos estariam ligados realmente a prática. Desse modo as competências e as habilidades estariam aplicadas de forma real, segundo os autores. Assim através do envolvimento do setor empresarial na educação traria de certa forma uma prévia preparação dos alunos para o mercado de trabalho. Quando se aborda problemas reais, os alunos se depararam com algumas habilidades em que as empresas necessitam para resolver seus problemas, tais como o processo de pesquisa investigativa, geração de hipóteses, conflitos, planejamento, busca por conteúdos relacionados e solução e geração de resultados. Ainda segundo o autor, quando se envolvem os alunos na investigação de casos reais e resolução de problemas, pode ajudar os custos empresarial, não que seja o alvo. A criatividade e o empenho dos alunos seriam algo a destacar, isto foi fato por meio das entrevistas desenvolvidas segundo o autor com as empresas engajadas neste processo de envolvimento com o setor de educação.

Para Morán (2015) é muito importante que as metodologias de ensino aprendizagem sejam acompanhadas por objetivos pretendidos pela instituição e aprendizagem aos alunos. Se a instituição quer que seus alunos sejam proativos, é necessário adotar metodologias em que os mesmos se envolvam em atividades, com cada vez mais interesse, em que tenham que tomar decisões e avaliar os resultados, com apoio de materiais relevantes para autoconhecimento.

Para Crawley *et al* (2007), os objetivos para os cursos de graduação em Engenharia, tem as seguintes propriedades:

- Ter a prática moderna da engenharia de modo que as intenções do objetivo fluam naturalmente nos papéis reais da profissão dos engenheiros;
- Ser abrangente o suficiente desenvolvendo ao máximo as práticas na educação em engenharia;
- Ser completo e consistente, na medida em que todos os conhecimentos, habilidades e atitudes esperados para a graduação do engenheiro estejam incluídos;
- Ser apresentado de forma suficientemente detalhada em que os tópicos específicos possam ser ensinados e aprendidos, estabelecendo as bases para o planejamento do currículo e avaliação baseada em resultados;
- Ser ligado a um processo de pesquisa que estabelecerá níveis de proficiência amplamente acordados que seria esperado de um engenheiro graduado;
- Expressar por meio de uma linguagem específica e formal, os objetivos de aprendizagem, o que deverá conduzir a uma interpretação coerente e avaliável do nível desejado de proficiência.

Segundo Gemignani (2012) o professor tem um papel importante, que é permitir que o estudante aprimore e melhore a visão de forma independente e autônoma, pois requer um esforço para ambos no sentido de verificar modelos e cenários de ensino. Ainda segundo o autor, o aprendizado por projetos caracteriza-se pela busca de informações sobre o problema escolhido com alguns componentes que são fundamentais para o sucesso de aprendizagem como uma sistematização da metodologia com algumas etapas, como as seguintes: observação da realidade; pontos chaves; teorização; hipóteses de solução; aplicação à realidade. Estas etapas são apenas um caminho no qual é articulado à participação individual e em grupo, sendo assim, uma equipe desenvolve a capacidade de acompanhar, mediar, analisar, verificar as necessidades, resultados e lacunas nos projetos em se que envolvem.

Para Bonatto *et al* (2012) a interdisciplinaridade é um elo entre o entendimento das disciplinas nas suas diversas áreas. Sua importância está relacionada ao fato da possibilidade de abranger temáticas e conteúdo, permitindo dessa forma recursos inovadores e dinâmicos, em que as aprendizagens são ampliadas.

Para Tavares (1999) o caminho interdisciplinar é amplo no seu contexto e nos revela um quadro que precisa ser redefinido e ampliado. Tal constatação induz a reflexão sobre a necessidade de professores e alunos trabalharem unidos, se conhecerem e se entrosarem para juntos vivenciarem uma ação educativa mais produtiva. O papel do professor é fundamental no avanço construtivo do aluno. É a partir dele que o professor pode captar as necessidades do aluno e o que a educação lhe proporcionar. A interdisciplinaridade do professor pode envolver e modificar o aluno quando ele assim o permitir.

Há várias razões por trás da mudança da educação tradicional para a liderada pelo projeto no ensino superior. Helle *et al* (2006) distinguem três categorias que são relevantes. Primeiro, há motivos profissionais: a aprendizagem deve ser mais baseada no trabalho e voltada para a prática profissional. Fomentar o pensamento crítico pode ser uma segunda razão para embarcar em uma mudança para a aprendizagem baseada em projetos. Motivos pedagógicos que compreendem uma melhor compreensão dos temas também justificam esta mudança na abordagem de aprendizagem.

2 Metodologia

O trabalho proposto está associado ao desenvolvimento de uma ponte de palitos seguiu-se pôr os procedimentos passados para os alunos sob um edital discutido perante e postado no sistema educacional da instituição para que os alunos leiam com mais entendimento. Edital possui todas as informações para o planejamento e execução do projeto pelos grupos. Algumas diretrizes são cabíveis aqui para ser mostrado, tais como, como desenvolver os relatórios, a importância do projeto para a formação do futuro engenheiro, as disciplinas e os professores envolvidos, ou seja, a matriz de contribuição, justificativa, objetivos a serem atingidos, os parâmetros de construção da ponte com as devidas limitações, os mecanismos de avaliação e notas de desempenho e o cronograma.

O manual de todos os projetos da instituição é elaborado pelos professores sob a supervisão dos coordenadores de curso, esse documento é todo revisado, segue as mesmas formas de avaliação e condução de outros projetos propostas na instituição. As diferenças ocorrem apenas pela bibliografia, na avaliação das pontuações da apresentação dos projetos e nas matrizes de contribuição.

A inovação que pode ser destacada aqui seria por conta das avaliações propostas pela instituição, trata-se dos "gates". Adiante é apresentado as avaliações em forma desses portais de entrada e de finalização:

O grupo está direcionado à três apresentações e entregar dois relatórios sendo um parcial e outro final (em forma de artigo), em uma escala de 0 (zero) a 10 (dez), segue a fórmula da equação 1 utilizada para as avaliações.

$$\text{(Média final) MF} = (0{,}1*\text{Gate1}) + (0{,}1*\text{Gate2}) + (0{,}1*\text{Gate3}) + (0{,}7*\text{Gate 4}) \qquad (1)$$

Onde:

Gate 1, representa a nota da primeira apresentação é estabelecido no primeiro mês de projeto, por exemplo, estando no segundo semestre seria agosto. Esta avaliação pode ser aplicada para uma apresentação oral realizada em grupo, sendo que são avaliados os conceitos abordados e habilidade de argumentação do tema para cada aluno do grupo.

Gate 2, representa apresentação do relatório parcial para o período de setembro seguindo o mesmo raciocínio do parágrafo anterior. Para esta avaliação seria a análise do relatório parcial que deve conter as informações sobre o desenvolvimento do projeto. Esta análise tem como objetivo básico, a orientação sobre a organização e a estruturação das informações contidas no relatório.

Gate 3, representa a nota da segunda apresentação, neste caso o período de novembro. Para esta avaliação é aplicada sobre a forma de apresentação realizada por um representante do grupo, sendo que este deve ter domínio dos conceitos abordados e habilidade de argumentação do tema, bem como a utilização de recursos multimídias.

Gate 4, representa nota da apresentação final e entrega de artigo também para o período em novembro. Os 70% de peso para este "Gate" são divididos em 50% de apresentação final realizada em grupo e 20% para com o artigo.

Com relação a apresentação final, que rege a parte mais importante do trabalho, ou seja, conceitual mais a formação integral do aluno tem os critérios de arguição também pré-definidos tais como:

- A capacidade de comunicação com uma postura adequada,
- Demonstrar clareza na exposição dos conceitos, comunicar eficazmente.

- Revelar a capacidade de argumentação e problematização;
- O uso de recursos gráficos de exibição e animação em 3D;
- Criatividade, ou seja, apresenta ideias inovadoras, demonstrar originalidade e revela espírito de iniciativa;

O protótipo em si é avaliado em função da relação peso suportado sobre peso total da estrutura, descrito na equação (2):

$$R = P_t / P_e \qquad (2)$$

Onde:

R – relação

P_t – carga máxima suportada pela ponte antes do colapso

P_e – peso total da ponte com todos seus elementos e acessórios

Com relação aos projetos os alunos têm a opção de escolher a maquete a ser construída, uma sugestão pode ser passada pelo professor de estrutura de construção civil, conforme a figura 1 a seguir. Isto, ajuda muito, apenas é lembrado aos alunos o destaque da criatividade.

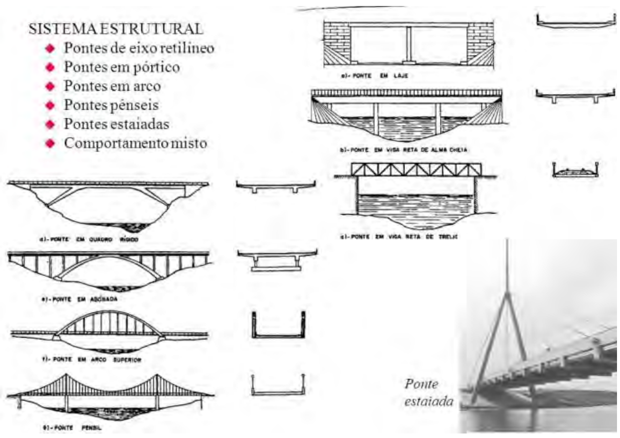

Figura 1 (a) Exemplos de ponte

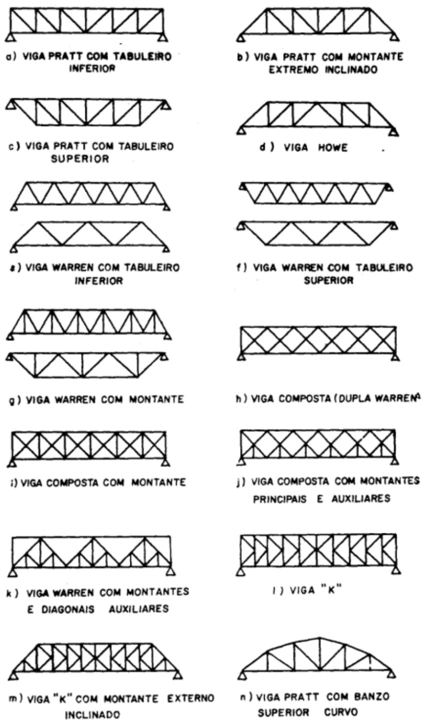

Figura 1 (b) Tipos de treliças

Para as limitações dimensionais da ponte de palitos é passado aos grupos as fotos do dispositivo de teste e a máquina de tração do Unisal de Lorena, ou seja, os limites máximo de construção das pontes. A seguir pode ser visualizado o dispositivo e a máquina do laboratório da instituição.

Por meio da figura 2 pode ser observado por meio da primeira e segunda imagem o dispositivo visto de frente e lateral, esse dispositivo foi desenvolvido pelos técnicos dos laboratórios de metodologia ativas do Unisal de Lorena. A terceira imagem representa o dispositivo na máquina com uma ponte para ser testada com cargas de compressão. Foi definido que para o comprimento da ponte em torno de 1 metro e a largura do dispositivo.

Antes da criação desse dispositivo era utilizado para os cálculos da ponte de palitos um sistema de medição de extensão chamado de "*Clipgage*" para os corpos de prova de tração e compressão. Assim com as medidas dos esforços de compressão era transformado em sinais digitais e também isso continuou com o uso do dispositivo, automaticamente então todos alunos assistem por meio do projetor o gráfico de tensão por deformação até atingir ruptura das pontes.

Figura 2. Imagem do dispositivo e da máquina de tração.

Uma ferramenta para os cálculos estrutural do protótipo foi proposta, se trata de um programa de domínio público chamado de "Ftool 3.01". Esse programa possui uma plataforma de trabalho para desenhos e cálculos matemáticos voltados para estruturas. O objetivo além de facilitar o desenvolvimento matemático, pode leva os alunos a terem contatos com futuros programas mais potentes e específicos da engenharia.

3 Resultados e Discussão

Os resultados obtidos nos projetos, são mais do que satisfatório para a instituição pois representou o envolvimento. A seguir na figura 2 por meio de sua imagem pode ser observado o programa utilizado pelos alunos para desenhar as treliças utilizados no projeto como mencionado na metodologia. A imagem mostra a um exemplo de início dos desenhos parecidos com o sistema CAD, este processo envolveu os professores das disciplinas de desenho e resistências das matérias junto com a disciplina de projetos. Como todo processo de projetos, os alunos foram auxiliados pelo professor no sentido de como iniciar um projeto assim um roteiro questões baseado em Slack foi passado para os alunos, conforme os itens a seguirem:

- O que é um projeto?
- Na disciplina e no curso de engenharia o quê seria mais importante de discutir: Projeto de produto, de serviços e de processos, e se todos são importantes quais os relacionamentos entre si?
- Destaque na construção do projeto a transformação, a especificação o detalhamento e a criatividade no projeto.
- Pesquise sobre padronização e modularização dos projetos.
- Quais as vantagens competitivas de um bom projeto?
- Especifique e detalhe as etapas do projeto, destaque uma possível utilização dos usuários do teu projeto, um possível concorrentes, as ideias dos funcionários, pesquisa e desenvolvimento, a avaliação e melhoria continua.
- Fale sobre prototipagem na elaboração dos projetos.
- Fale sobre projeto auxiliado por computador (CAD).
- Na construção de um projeto o que mais deve ser pensado: resolução rápida de conflito, estrutura organizacionais do projeto ou desenvolvimento simultâneo.

Na primeira vista os alunos quando abordaram esses questionamentos ficaram apreensivos pelas somatórias de exigências, porém no desenvolvimento destas questões entenderam que seria muito útil para desenvolvimento de projetos futuros na vida de um engenheiro e que isso seria um roteiro que usariam em suas vidas como profissional, esse foi o grande retorno.

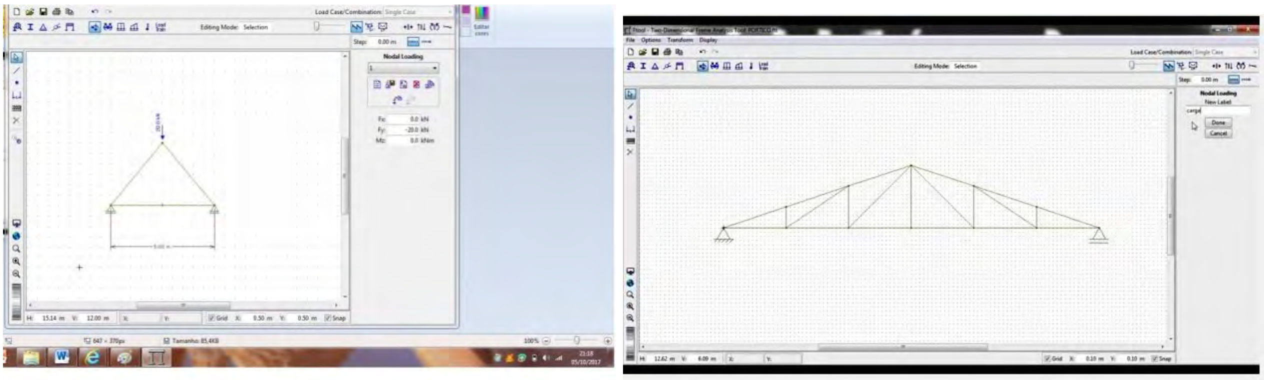

Figura 3. Imagens do programa Ftool para as estruturas da ponte de palitos

O resultado dos trabalhos realizados pelos alunos pode ser visualizado por meio das imagens da figura 4 a seguir das pontes feitas de cursos que de alguns cursos de engenharia da Unisal de Lorena, são pontes feitas pelas turmas de segundo período. Esses alunos já vêm de outro projeto interdisciplinar do primeiro período pois todos os períodos têm projetos, assim esses alunos já se atuam com uma certa autonomia e entendem o procedimento e mecanismo dos projetos.

Figura 4. Imagens das pontes feitas no projeto ponte de palitos.

Os objetivos de conteúdos que o projeto de ponte de palitos foram abordados durante todo o projeto pode-se destacar tais como, o algebrismo, cálculo de treliças, de resistência dos matérias pois era necessário conhecimento da resistência de cada palito para extrapolar todo o conjunto, foi explorado o desenho auxiliado por computar "CAD", conceito de ciências dos materiais, projeção de estruturas e pontes, ensaios mecânicos, tais como ensaio de tração e compressão, propriedade mecânicas e análise computacional. Outros aspectos relacionados foram dispostos e observados para a formação integral dos alunos, ou seja, trabalhos em equipes, resolução de problemas e conflitos, dinamismos, pesquisas e estudos de programas computacionais, liderança, divisão de tarefas e planejamento e controle do planejado, disciplina e respeito ao próximo e finalmente o calendário.

Pensando neste sentido, foi encaminhado aos alunos um questionário para medir a intensidade dos projetos em vários aspectos, é passado aos alunos no começo do semestre e durante o projeto eles respondem de acordo com a expectativa, situação corrente e finalização. O que pode observar nas respostas dos projetos que como qualquer outro projeto de engenharia os alunos perceberam a importância de se ter para a sua formação durante o curso e que eles também se conheceram como estudantes e situação futura. Esse questionário possui cunho informativo, direcionado a formação dos alunos e percepção para as coordenações no objetivo de melhoria contínua da disciplina de projetos. Por meio da imagem a segui pode ser visualizado uma parte do questionário. Deve-se observado que todo questionário foi elaborado em conjunto aos professores que trabalham com ética da instituição já que envolve perguntas aos nossos alunos.

AVALIAÇÃO HABILIDADES E ATITUDES

NOME: RA:

[ ] EXPECTATIVA [ ] PERCEPÇÃO

COMPETÊNCIAS	Nível de Proficiência: Ser experimentado ou expostos a ...	Ser capaz de participar e contribuir para ...	Ser capaz de compreender e explicar ...	Ser hábil na prática ou aplicação a ...	Ser capaz de liderar ou inovar em ...
HABILIDADES E ATITUDES: PESSOAIS E PROFISSIONAIS					
Raciocínio de Engenharia e Resolução de Problemas (Identificação e formulação do problema por modelos, estimativas, análises à recomendação de soluções)					
Experimentação e Descoberta do Conhecimento (Formulação e testes de Hipóteses, levantamento da literatura eletrônica, experimentos)					
Pensamento Sistêmico (Holístico, visão do todo, urgência, priorização, foco, trade-offs e equilíbrio na resolução)					
Habilidades e atitudes PESSOAIS (iniciativa e vontade de assumir riscos, perseverança e flexibilidade, criativo, crítico , gestão de tempo e de recursos)					
Habilidades e atitudes PROFISSIONAIS (Comportamento ético, integro, responsável, atualização continua, planejamento pró-ativo para a carreira)					

Figura 5. Questionário de entrada para os alunos dos projetos UNISAL.

Ao final do semestre o mesmo questionário foi aplicado de modo a mediar a percepção dos alunos quanto ao desenvolvimento das competências listadas. Até o momento final da submissão, os dados ainda estavam sendo compilados.

4 Conclusão

A aplicação da aprendizagem baseada em projetos sem dúvida foi o caminho que melhor rendeu em termos de objetivos a serem atingidos, tais como, formação de time, liderança, tratamento de conflitos e fixação de conceitos.

O projeto de ponte de palitos está sendo uma experiência para instituição muito interessante, pois foi tão importante e aceita pelos alunos que acabou virando disciplina do curso e que os alunos realmente entenderiam esse projeto de inovação e metodologia ativa.

Foram atingidos os resultados esperados, tais como o envolvimento de outros professores, coordenação e todos os alunos, foram adquiridos os conhecimentos e conteúdos por meio dos projetos. Todo o projeto foi assistido pelo professor integrador. Neste caso, o professor integrador da disciplinar acompanhou de perto o desenvolvimento do artigo, pois foi passado para eles e ensinado como fazer um artigo em forma a partir do "*Template*" que a própria instituição trabalha em suas revistas acadêmicas.

As pontes desenvolvidas pelos alunos quase todas atingiram os objetivos pela relação da fórmula apresentadas as eles, as pontes se apresentaram de forma criativa, funcional, com os custos elaborados visando o mínimo possível, sempre buscando a economia e obedecendo as regras da apresentação.

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Interdisciplinary Training promoted by the students of the Industrial Engineering Course

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Abstract

Professional training is always important and should be continued even more in the situation of being out of the job market. In addition, allowing the student a teaching practice becomes relevant in completing the egress training by developing skills that can be improved for a future profession. Aligning these two scenarios the present article describes an interdisciplinary project applied in the 8th semester of the Production Engineering course in which groups of students should propose and teach a short course with subjects related to the subjects studied in the semester. The proposal is to intercede with the next community, prioritizing unemployed who have an interest in qualifying in order to improve the level of employability enabling new opportunities in the labor market. Thus, the following themes are proposed for elaboration, organization, application and evaluation: Quality Tools; Inventory Management; Logistics; Maintenance; Philosophy 5S and Housekeeping; Ergonomics and Occupational Safety. In addition to the pedagogical academic characteristic, the social context is a striking point in this interdisciplinary project, these being one of the competences advocated by INIOIATIVA CDIO to the egress of the Engineering Courses.

Keywords: Professional Qualification, Employability, Interdisciplinary Project, Social Context, Industrial Engineering.

Capacitação Interdisciplinar promovida pelos alunos do curso de Engenharia de Produção

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Resumo

Capacitação profissional sempre é importante devendo ser de maneira continuada ainda mais na situação de estar fora do mercado de trabalho. Além disso, possibilitar ao aluno uma prática docente se faz relevante no complemento da formação do egresso desenvolvendo habilidades que poderão ser aperfeiçoadas para uma futura profissão. Alinhando estes dois cenários o presente artigo descreve um projeto interdisciplinar aplicado no 8° semestre do curso de Engenharia de Produção na qual grupos de alunos deveriam propor e ministrar curso de curta duração com temas relacionados as disciplinas estudadas no semestre letivo. A proposta é interceder junto à comunidade próxima, priorizando desempregados que tenham interesse em qualificar de modo a melhorar o nível de empregabilidade possibilitando a novas oportunidades no mercado de trabalho. Assim, são propostos para elaboração, organização, aplicação e avaliação os seguintes temas: Ferramentas da Qualidade; Gestão de Estoque; Logística; Manutenção; Filosofia 5S e Housekeeping; Ergonomia e Segurança do Trabalho. Além da característica acadêmica pedagógica, o contexto social é ponto marcante neste projeto interdisciplinar, sendo estas uma das competências preconizadas pela INICIATIVA CDIO ao egresso dos cursos de Engenharia.

Palavras-chaves: Capacitação Profissional, Empregabilidade, Projeto Interdisciplinar, Contexto Social, Engenharia de Produção.

1 Introdução

A prática docente no ensino de engenharia exige não apenas um domínio de conhecimentos teóricos e práticos, mas, também, um compromisso semelhante ao exigido para o exercício de qualquer profissão. O que preocupa profundamente, porém, é que pouco se privilegia o papel do docente de engenharia como um dos principais agentes do processo de formação dos futuros engenheiros (PEREIRA *et al*, 2014).

Segundo Libâneo (1998), à docência, entendida como o ensinar e o aprender, está presente na prática social em geral e não apenas na escola, pois, em qualquer âmbito em que o pesquisador/profissional atue, exercerá uma ação docente. As transformações técnicas, sociais, políticas, econômicas da sociedade contemporânea consolidam o entendimento da educação como fenômeno plurifacetado, que pode ocorrer em vários espaços, institucionalizados ou não. Nas várias esferas da sociedade, surge a necessidade de disseminação e internalização de saberes e modos de ação (conhecimentos, conceitos, habilidades, procedimentos, crenças, atitudes), acentuando o poder pedagógico dos vários agentes educativos na sociedade e não apenas nas tradicionais formas familiar e escolar.

Segundo Booth, Sauer e Lima (2011), capacitar o engenheiro a “aprender a aprender” e a atuar em seu meio profissional com competência são objetivos que devem orientar os rumos do processo educativo de sua formação. Parece estar cada vez mais evidente que qualquer remodelação na educação tecnológica deve ser realizada com a inclusão de estudos que provoquem análises críticas entre ciência, tecnologia e sociedade para que, além de profissionais competentes em suas habilidades específicas haja a possibilidade de formar cidadãos comprometidos com o desenvolvimento econômico e ambientalmente sustentável da sociedade. (BAZZO; BARROS, 2011).

Diante deste contexto, o objetivo geral deste artigo é apresentar o desenvolvimento do projeto interdisciplinar do 8° semestre do curso de Engenharia de Produção do Centro Universitário Salesiano de São Paulo (UNISAL) na sua unidade de Lorena, na qual foi definido que os alunos deveriam organizar e ministrar cursos de curta duração para capacitação profissional de temas propostos referente as disciplinas do semestre corrente atendendo da comunidade local, priorizando aqueles que necessitam qualificação para recolocação no mercado de trabalho.

2 Contextualização Sistemática da Literatura

2.1 Projetos Interdisciplinares

Para Bonatto *et al* (2012) a interdisciplinaridade é um elo entre o entendimento das disciplinas nas suas diversas áreas. Sua importância está relacionada ao fato da possibilidade de abranger temáticas e conteúdo, permitindo dessa forma recursos inovadores e dinâmicos, em que as aprendizagens são ampliadas.

A interdisciplinaridade atendendo a realidade do desenvolvimento da Engenharia de maneira geral, corresponde a uma consciência da realidade no modo de pensar, que resulta num ato de troca, reciprocidade e integração entre áreas diferentes do conhecimento, visando tanto a produção de novos conhecimentos, quanto a resolução de problemas, de modo global e abrangente. (FAVARÃO; ARAÚJO, 2004). Para os professores permanentemente acadêmicos, este processo é novidade até os dias de hoje.

Segundo Van Hattum-Janssen (2010), há dois elementos comuns nas diferentes definições de abordagens de projetos. O primeiro é o envolvimento ativo do estudante. Numa abordagem de projeto, o aluno não é mais um receptor passivo do conhecimento, mas passa a construir ativamente seu próprio conhecimento. As abordagens de projeto são, por definição, centradas nos alunos. O segundo elemento comum é a natureza de vida real dos problemas com que os alunos se defrontam, a fim de melhorar a motivação e o entendimento da prática do futuro profissional.

Para Soares (2013), neste modelo cada equipe de alunos desenvolve um projeto comum para todo o semestre. Neste projeto devem desenvolver competências de todas as disciplinas curriculares do semestre de forma integrada. O projeto tem dois objetivos: aplicar o conteúdo das disciplinas na tarefa proposta e contribuir para uma compreensão mais profunda desse conteúdo.

Segundo Veraldo Jr *et al* (2016), como forma de utilizar métodos ativos no ensino dos seus alunos, os cursos de engenharia do Centro Universitário Salesiano de São Paulo (UNISAL) em sua unidade de Lorena, estabelecem em sua matriz curricular, projetos interdisciplinares ao longo de todo o curso, envolvendo o máximo de disciplinas do respectivo semestre. Nos quatro primeiros, os projetos são básicos a todos os cursos devido à similaridade das disciplinas. Para os quatro últimos, os projetos são específicos de acordo com a modalidade da Engenharia (Civil, Computação, Elétrica, Mecânica e Produção). A aplicação de projetos interdisciplinares na grade curricular dos cursos de Engenharia vem do compromisso da Instituição estudada, em desenvolver a integração das disciplinas mostrando a abrangência e principalmente a conexão entre os conteúdos.

2.2 Iniciativa CDIO

Analisando as necessidades da Educação em Engenharia segundo as exigências e conselhos da indústria e de outras partes interessadas em relação aos conhecimentos, habilidades e atitudes desejadas dos futuros engenheiros sintetizando em listas de atributos, as instituições de ensino foram conduzidas por uma necessidade mais básica, ou seja, a razão pela qual a sociedade precisa de engenheiros, em primeiro lugar (CRAWLEY, BRODUER e SODERHOLM, 2008). Os autores descrevem o ponto de partida da Iniciativa CDIO (*Conceived-Design-Implement-Operate*) na atualização da necessidade subjacente de educação de engenharia acreditando que todo engenheiro graduado deve ser capaz de: Conceber-Projetar-Implementar-Operar produtos, processos e sistemas complexos de engenharia. O engenheiro deve ser capaz de trabalhar em ambientes modernos baseados em equipe na qual terão a responsabilidade de executar uma sequência de tarefas, a fim de projetar e implementar um produto, processo ou sistema dentro de uma organização.

Importante salientar que nem todos os professores dos cursos de Engenharia são engenheiros, portanto dois dos pilares do processo de aprendizagem propostos pela INICIATIVA remete a formação dos professores, seja no ambiente pedagógico, seja no ambiente profissional específico da disciplina.

A Iniciativa tem três objetivos gerais de modo a desenvolver os estudantes para que possam demonstrar (ZAMYATINA *et al*, 2014):

- Conhecimento aprofundado dos princípios básicos relacionados à engenharia de sua profissão;
- Especialização em desenvolvimento e uso de novos produtos e sistemas;
- Compreensão da importância e do valor estratégico do desenvolvimento tecnológico da sociedade.

Como parte das competências necessárias para a completa formação do egresso em Engenharia, Crawley *et al* (2007) apresenta traz as habilidades as habilidades e atributos pessoais e profissionais; habilidades interpessoais: trabalho em grupo e comunicação; além do entendimento em conceber, projetar, implementar e operar sistemas de uma empresa no ambiental além do envolvimento com o contexto social. Esta contextualização social envolve regulamento, papéis, responsabilidade e o impacto da Engenharia nos valores da sociedade e perspectiva global.

3 Projeto Aplicado

O referido projeto pretende possibilitar aos alunos do 8° semestre da Engenharia de Produção experimentar os conhecimentos, conceitos e aprendizados adquiridos até o presente momento do curso com o objetivo de elaborar, organizar e aplicar treinamento de curta duração com carga horária máxima de 12h dos seguintes temas propostos:

- Ferramentas da Qualidade;
- Gestão de Estoque;
- Logística;
- Manutenção;
- *Lean Manufacturing* (Produção Enxuta);
- Ergonomia e Segurança do Trabalho.

O fluxo de atividades do projeto é descrito na Figura 1.

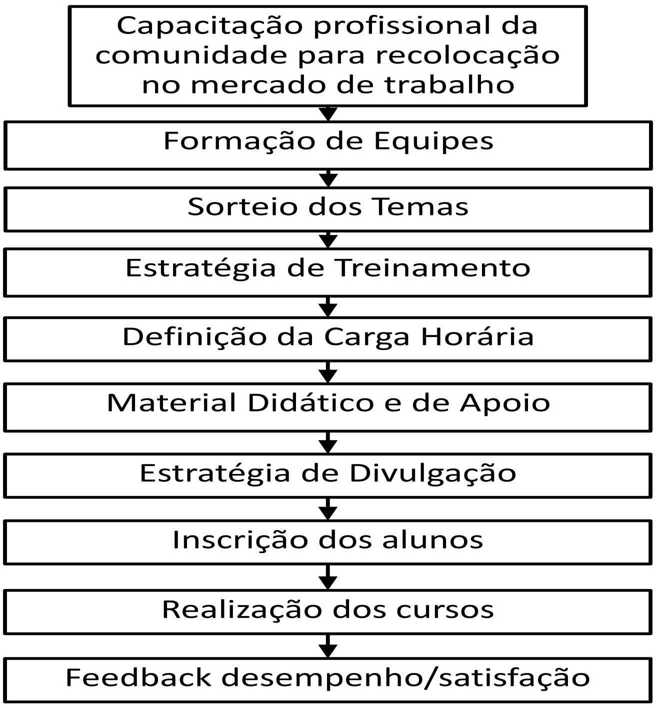

Figura 1. Fluxo do projeto interdisciplinar

O projeto é realizado em um período de 12 semanas em paralelo ao desenvolvimento das disciplinas do semestre facilitando a atuação conjunta do professor integrador e demais professores trabalhando como facilitadores nas atividades específicas. O Quadro 1 apresenta os eventos a cada *gate*.

Quadro 1 – Descrição dos *gates*

Gates	**Evento**
Kick off	Comunicação aos alunos e demais professores envolvidos
01	Exploração em aula dos conteúdos previstos no projeto
02	Tutoria do projeto
03	Relatórios parciais (Material didático e estratégias do curso)
04	Aprovação do Material
05	Execução e coordenação do treinamento
06	Pesquisa de Opinião e Feedback dos participantes
07	Relatório Final
Gate Final	Avaliação final e comunicação dos resultados

3.1 Justificativa do Projeto

Para o desenvolvimento dos futuros engenheiros, o interesse em participar das questões da comunidade e do contexto social do país e da região onde atuam, vivenciando uma experiência própria e real, contribuindo na formação profissional. Além de proporcionar capacitação de pessoas, a satisfação pessoal em participar de atividades voluntárias poderá ser um diferencial no mercado de trabalho.

Outro resultado esperado remete ao acesso ao ambiente acadêmico institucional por parte dos participantes dos cursos podendo despertar a continuidades dos estudos (em todas as esferas: graduação, pós-graduação; extensão), escolhendo o UNISAL como opção.

3.2 Contribuição das disciplinas

As disciplinas integrantes do projeto interdisciplinar, incluindo os professores e suas respectivas contribuições são apresentadas no Quadro 2.

Quadro 2 - Matriz de Contribuição das Disciplinas

Disciplinas	**Professor**	**Contribuições**
Gestão da Qualidade (Integradora)	Jorge Rosa	Capacitação da gestão e implementação de curso de treinamento na área da qualidade, produção e aprofundamento dos conceitos da grade curricular
Planejamento e Controle da Produção	Cleginaldo de Carvalho	Capacitação na disseminação e aplicação das ferramentas da manufatura enxuta, os benefícios no aumento da produtividade e de redução de custos em diferentes sistemas de produção.
Logística e Administração de Materiais	Paulo França	Sistemas, equipamentos e técnicas de movimentação e armazenagem de cargas fracionadas e a granel. Recepção, agregação/desagregação e despacho de cargas. Estratégias de controle e operação de armazéns; Gerenciamento de estoques.
Ergonomia, Saúde e Segurança do Trabalho	Danielle Rodrigues	Conceitos gerais: ergonomia, saúde e segurança no trabalho. Acidentes do trabalho, doenças profissionais e do trabalho. Métodos de análise de riscos à saúde e ambiental devidos à exposição a agentes físicos, químicos e biológicos. Métodos de análise de acidentes.
Custos Gerenciais	Wagner Godoi	Capacitação avaliação de estoques, sistemas de custeio, custo-padrão, ponto de equilíbrio, alavancagem operacional, formação do preço de venda.

3.3 Método de Avaliação

O projeto interdisciplinar será avaliado de maneira coletiva numa escala de 0 (zero) à 10 (dez) nos seguintes itens que seguem:

- (40%) Material Didático e Estratégias;
- (40%) Relatório Final;
- (10%) Participação nas atividades;
- (10%) Grau de avaliação e Feedback dos participantes.

4 Considerações Finais

Até o presente momento o projeto foi executado até a aprovação do material (*gate* 4). A viabilidade do público alvo será definida a partir de listagem de pessoas desempregadas disponibilizada pelo PAT (Programa de Atendimento ao Trabalhador) da cidade de Lorena.

Os possíveis candidatos serão contatados pelo respectivo grupo de alunos para cada curso definido esperando assim, um relacionamento maior dos instrutores. Com o projeto em andamento ficou definido que os alunos também auxiliarão aos candidatos a elaboração correta do currículo e principalmente, criar perfil no *Linkedin* (ferramenta virtual para contatos profissionais).

Além disso, em conjunto com o curso de Gestão de Recursos Humanos será feito ao final de cada curso, um processo de orientação vocacional de modo a direcionar corretamente não apenas o processo de qualificação mas também, qual o perfil de vaga a ser escolhido pelo candidato.

Como propostas de melhorias neste processo de capacitação e para que um maior público pudesse ser beneficiado com a qualificação profissional proposta, futuros cursos poderão ser oferecidos a distância por meio de vídeo-aulas, material didático e tutoria disponibilizado em AVA (Ambiente Virtual de Aprendizagem) podendo ser acessado tanto por computadores quanto por *smartphone*.

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Continuous Improvement Applied to Homemade Beer Brewing in the Industrial Engineering Teaching

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Abstract

The vocational education system has been object of discussions primarily focusing on curricular organizations and training courses, with less emphasis on learning methodologies aimed at building professional skills. Some methodological strategies of differentiated education have been developed in order to promote changes in their teaching practices, with a meaningful view to learning. The development of interdisciplinary projects is one of these innovative methods of strategies in which the student works in order to solve or simulate a problem or process through a learning method focused on the student who leaves the role of passive knowledge receiver and takes the place of their own learning protagonist. The use of these projects in Unisal, the first Brazilian institution to participate in the CDIO Initiative, is a striking feature in all semesters of the Engineering courses, taking into account the experiences proposed in Standard 5. This article presents the project carried out in the tenth and last semester of the Industrial Engineering course, in which it was proposed to the students the development of the manufacturing process having as final product the craft beer. To carry out the project, the students went through the conception stages (to idealize the product to be developed), to design (establishing the manufacturing needs), to implement (characterizing the inputs and equipment) and to operate (producing the craft beer). In addition, the teams should develop the business plan and the market analysis in which they defined to act and at the end of the semester, presented the final report with the complete process of developing the brewing culminating with the tasting process. This process of experimentation will be carried out by an assessment bank composed of specialists and professors of the project disciplines that are Project Management, People Management, Business Plan Development and Strategic and Organizational Management. The practice of craft beverage production not only opens the door to the emergence of new breweries, but also creates opportunities for businesses related to the offering of raw materials and equipment, promoting entrepreneurship in students. The summary should present in its structure of four basic elements, namely: a brief introduction; study objective; methodological procedures and; major results.

Keywords: Practice. Homemade Beer. Interdisciplinary Project. Industrial Engineering, Standard 5.

Melhoria Contínua Aplicada ao Projeto de Fabricação de Cerveja Artesanal no Ensino da Engenharia de Produção

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Resumo

O sistema de ensino profissional tem sido objeto de discussões centradas principalmente na organização curricular e nos cursos de formação, e com menos ênfase nas metodologias de aprendizagem que visam a construção de competências profissionais. Algumas estratégias metodológicas da educação diferenciada têm sido desenvolvidas para promover mudanças em suas práticas de ensino, com uma visão voltada para a aprendizagem. O desenvolvimento de projetos interdisciplinares é um desses métodos inovadores de estratégias em que o aluno trabalha para resolver ou simular um problema ou processo através de um método de aprendizagem focado no aluno, o qual deixa o papel de receptor passivo de conhecimento e assume o papel de protagonista da aprendizagem. O uso desses projetos no Centro Salesiano de São Paulo (UNISAL), a primeira instituição brasileira a participar da Iniciativa CDIO, é uma característica marcante em todos os semestres dos cursos de Engenharia, levando em consideração as experiências propostas no *Standart* 5. Este artigo apresenta alguns pontos de melhoria no projeto realizado no décimo e último semestre do curso de Engenharia de Produção, onde foi proposto aos alunos o desenvolvimento do processo de fabricação tendo como produto final a cerveja artesanal, a fim de desenvolver características necessárias a um engenheiro de produção (trabalho em equipe, gestão de conflitos, resolução de problemas, articulação teoria/prática e apresentação de uma solução/produto). Para realizar o projeto, os alunos passaram pelos estágios de concepção (idealizando o produto a ser desenvolvido), projeto (estabelecendo as necessidades de fabricação), implementação dos processos (caracterização das entradas e equipamentos) e operar (produzir a cerveja artesanal). Além disso, as equipes deveriam desenvolver o plano de negócios e a análise de mercado em que definiram para atuar e no final do semestre, apresentou o relatório final com o processo completo de desenvolvimento da cervejaria que culminou com o processo de degustação. O processo foi realizado e avaliado por especialistas e professores das disciplinas do projeto

Palavras-chaves: Prática, Cerveja Artesanal, Projeto Interdisciplinar, Engenharia de Produção, Standard 5.

1 Introdução

As metodologias baseadas na aprendizagem ativa voltadas para a engenharia são efetivadas de variadas formas. As metodologias podem ser baseadas na solução de problemas (como o PBL - *Project Based Learning*), podem priorizar o trabalho a partir de projetos (PLE - *Project Led Education*), podem organizar o processo de aprendizado (*Project Work*), ou ainda, podem ser baseadas em experiências com projetos interdisciplinares. De qualquer forma as antigas práticas pedagógicas de transmitir o conhecimento devem dar lugar ao novo papel do educador enquanto facilitador em um processo de parceria com o estudante.

O projeto interdisciplinar faz parte da vida real e sua introdução é necessária nos programas regulares estabelecendo diferentes maneiras de aprendizagem propiciando a cooperação entre os estudantes independente de quão difícil é a sua organização (POLUTNIK *et al*, 2013). Além disso, é importante salientar como característica do projeto interdisciplinar a aprendizagem ativa do aluno, pois a realização prática do trabalho desenvolvido é resultado fundamental deste processo de ensino. Os projetos interdisciplinares contribuem efetivamente no aprendizado do aluno, pois consistem numa metodologia que enfatiza o trabalho em equipe, a resolução de problemas variados e a articulação teoria/prática, na realização de um projeto que culmina com a apresentação de uma solução/produto a partir de uma situação real, relacionada com o futuro contexto profissional (POWELL; WEENK 2003). A prática pedagógica por meio do desenvolvimento destes projetos interdisciplinares é uma forma de conceber uma capacitação que envolve aluno, professor, recursos disponíveis e todas as interações que se estabelecem no ambiente de aprendizagem. Este ambiente é criado para promover a interação entre todos os seus elementos, propiciar o desenvolvimento da autonomia do aluno e a construção de conhecimentos de distintas áreas do saber, na busca de informações significativas para compreensão, representação e resolução de uma situação-problema (ALMEIDA, 1999).

A escolha entre uma e outra metodologia, para o caso deste artigo definiu-se pelo projeto interdisciplinar, determina o tipo de profissional que se pretende formar. E, na perspectiva do século XXI, a necessidade é formar profissionais capazes de imaginar e elaborar novas alternativas, progredir e aperfeiçoar conceitos. Para isso, é importante, além da escolha da prática, migrar de uma visão fragmentada para uma visão globalizada; do disciplinar para o inter e transdisciplinar, uma vez que a realidade atual não permite mais que as instituições superiores de ensino entreguem ao mercado de trabalho um profissional com o mesmo perfil de vinte anos passados, desta forma as instituições necessitam acompanhar o desenvolvimento na tecnologia e as mudanças no comportamento humano, para assim, permitir o desenvolvimento das potencialidades intelectuais que conduzam o aluno ao paradigma do aprender a aprender para que ele venha a ser protagonista de sua própria aprendizagem (CUNHA; SOUZA Jr, 2007).

2 Desenvolvimento do Projeto

Metodologias baseadas na aprendizagem ativa utilizando projetos interdisciplinares utilizadas no Centro Universitário Salesiano de São Paulo (UNISAL), a primeira instituição brasileira a participar da Iniciativa CDIO, é uma característica marcante em todos os semestres do curso de Engenharia de Produção (VERALDO JR *et al*, 2016a) e o projeto de fabricação de cervejas artesanais está sendo realizado pelo segundo ano consecutivo (BARBOSA NETO *et al*, 2016) o que nos permitiu, utilizando a algumas ferramentas de qualidade, estabelecer pontos de melhorias no desenvolvimento do projeto.

O projeto é aplicado no 10º semestre (último do curso de Engenharia Industrial) onde é proposto aos alunos um trabalho em grupo e limitado a 11 pessoas e com o escopo do projeto contemplando a idealização, elaboração e execução de um processo de fabricação de cerveja artesanal. Para o desenvolvimento das atividades necessárias segue-se os estágios de concepção (idealização do produto a ser desenvolvido), processos (estabelecimento de necessidades de fabricação), implementação (caracterização de insumos e equipamentos) e operação (produção da cerveja artesanal), além disso, os times devem desenvolver uma análise de mercado e um plano de negócios. Após o planejamento das atividades, é necessário conhecer o as etapas do processo de fabricação de cerveja (Mostura, Fervura, Fermentação, Maturação e Engarrafamento), uma vez que para o processo de avaliação é realizado uma degustação do produto final. Por fim, as contribuições das disciplinas são apresentadas no Quadro 1:

Quadro 01 - Matriz de Contribuição das Disciplinas

Disciplinas	**Professor**	**Contribuições**
Gestão de Projetos	Lucio	Implementação de uma metodologia de gestão de projetos. Conceitos de Project Management Body of Knowledge (PMBOK)
Gestão de Pessoas (Integradora)	Paulo França	Organização de equipes, seus papéis e suas responsabilidades. Gerenciamento de conflitos. Acompanhamento técnico do processo de fabricação
Gestão Estratégica e Organizacional	Humberto Felipe	Desenvolvimento estratégico de equipes. Elementos de planejamento e organização. SWOT
Gestão de Negócios	André Ortiz	Análise de mercado. Processo de pesquisa. Definição e caracterização do produto.
Simulação em Engenharia de Produção	Antônio Silva	Desenvolvimento de modelos determinísticos e probabilísticos, capazes de prever comportamentos de sistemas, gerando-se dados para tomar as melhores decisões

2.1 Aplicação da Avaliação de habilidades e atitudes

No projeto de 2017, logo após a apresentação do projeto foi iniciado um processo de avaliação a fim de medir a percepção dos estudantes antes e depois do desenvolvimento do projeto. O processo de avaliação do projeto interdisciplinar consiste em entender através da perspectiva dos alunos, individualmente, uma vez que cada jurisdição é afetada no desenvolvimento da atividade (VERALDO JR *et al.*, 2016b). No total, 41 alunos participaram da competência de avaliação.

A tabela 1 mostra a avaliação de habilidades e atitudes onde são evidenciados as competências e o nível de proficiência, os maiores valores estão destacados na cor azul. Esta prática não havia sido utilizada no projeto de 2016.

Tabela 01 – Avaliação de Habilidades e Competências

AVALIAÇÃO HABILIDADES E ATITUDES					
NOME:					
[ ] EXPECTATIVA [ ] PERCEPÇÃO	Nível de Proficiência				
COMPETÊNCIAS	Ser experimentado ou expostos a . .	Ser capaz de participar e contribuir para . .	Ser capaz de compreender e explicar . .	Ser hábil na prática ou aplicação a..	Ser capaz de liderar ou inovar em . .
HABILIDADES E ATITUDES: PESSOAIS E PROFISSIONAIS					
Raciocínio de Engenharia e Resolução de Problemas (Identificação e formulação do problema por modelos, estimativas, análises e recomendação de soluções)	15%	34%	27%	15%	10%
Experimentação e Descoberta do Conhecimento (Formulação e testes de Hipóteses, levantamento da literatura eletrônica, experimentos)	17%	27%	22%	29%	5%
Pensamento Sistêmico (Holístico, visão do todo, urgência, priorização, foco, trade-offs e equilíbrio na resolução)	12%	22%	17%	29%	20%
Habilidades e atitudes PESSOAIS (Iniciativa e vontade de assumir riscos, perseverança e flexibilidade, criativo, crítico , gestão de tempo e de recursos)	2%	22%	15%	37%	24%
Habilidades e atitudes PROFISSIONAIS (Comportamento ético, íntegro, responsável, atualização contínua, planejamento pró-ativo para a carreira)	2%	17%	17%	39%	24%
HABILIDADES INTERPESSOAIS: COMUNICAÇÃO E EQUIPE MULTIDISCIPLINAR					
Trabalho em Equipe (Formação de Equipes Eficazes em liderança, operação técnica de maneira evolutiva)	2%	27%	10%	32%	29%
Comunicação (Estratégia e estrutura por meio da escrita, oral, gráfica e inter-pessoais)	5%	20%	22%	37%	17%
CONCEBER, PROJETAR, IMPLEMENTAR E OPERAR SISTEMAS NA EMPRESA E NO CONTEXTO SOCIAL					
Contexto Social e Externo (Regulamento, papéis, responsabilidade e o impacto da engenharia nos valores da sociedade, perspectiva global)	17%	34%	24%	22%	2%
Contexto Empresarial e Negócios (Culturas e estratégias diferentes, metas, planejamento, empreendedorismo técnico, sucesso nas Organizações)	20%	29%	27%	17%	5%
Conceber Sistemas de Engenharia (Metas, funções, requisitos, conceitos e modalagem da arquitetura gerenciando o desenvolvimento do projeto)	15%	29%	24%	24%	7%
Projetar Sistemas (Desenvolver as abordagens em cada fase do projeto utilizando conhecimentos multidisciplinares e muti-objetivos)	17%	29%	17%	32%	5%
Implementar Sistemas (Estabelecer, verificar, validar e certificar o processo de implantação utilizando e integrando hardware e software)	7%	44%	24%	17%	7%
Operar Sistemas (Desenvolver e gerenciar as operações otimizadas, incluindo treinamentos, melhorias e evoluções no apoio ao ciclo de vida do sistema)	12%	54%	15%	15%	5%
Conduzir Empreendimentos na Engenharia (Criar uma visão como propósito nas soluções e entregas exercitando a inovação e invenção)	10%	32%	24%	15%	20%
Empreendedorismo (Fundação, formulação, liderança no desenvolvimento do plano de negócios, capitalizando recursos e propriedade intelectual)	5%	29%	20%	34%	12%

2.2 Desenvolvimento do Projeto

Após serem entendidos o escopo, a contribuição de cada disciplina e os objetivos do projeto, passamos ao próximo passo definindo um cronograma de atividades (quadro 02). Na data pré-determinada no cronograma, um membro de cada equipe apresentou as atividades realizadas e próximos passos.

Quadro 02 – Cronograma do Projeto Interdisciplinar

Data	**Gates**	**Evento**
Ago 07	Kick off	Orientações do especialista em cerveja
Ago 24	01	Definição dos componentes dos times, das responsabilidades e do plano de atividade (pesquisas, cálculos, etc.)
Ago 31	02	Processo de escolha (mercado, custos, viabilidade); Proposta de projeto
Set 14	03	Benchmarking; Modelo de preparação preliminar (fluxo de processo); Definição de indicadores de controlo (financeiros, lead time, outros)
Set 21	04	Recursos, materiais e equipamentos
Out 19	05	Fabricação (Operação); Controle de indicadores
Nov 09	06	Pontos críticos; Melhorias aplicadas; Novo processo (fluxo)
Nov 30	07	Teste de degustação de cerveja (incluía a entrega de um artigo)

O projeto é realizado, normalmente, em um período de 12 semanas na mesma época do semestre das disciplinas, sua realização é possível devido a uma ação conjunta dos professores que trabalharam como facilitadores dos grupos nas atividades específicas de cada disciplina e na sequência da data de entrega de cada *gate*. Aqui tivemos outro ponto de melhoria: as apresentações dos *gates* pelos grupos em 2016 foram realizadas, conforme o quadro 03, todas as semanas e durante as aulas do facilitador, o que prejudicou o desenvolvimento da disciplina durante o semestre. Desta forma, foi alterado a organização das apresentações, as quais ocorrem, agora, em apenas três semanas e durante as aulas da disciplina correspondente.

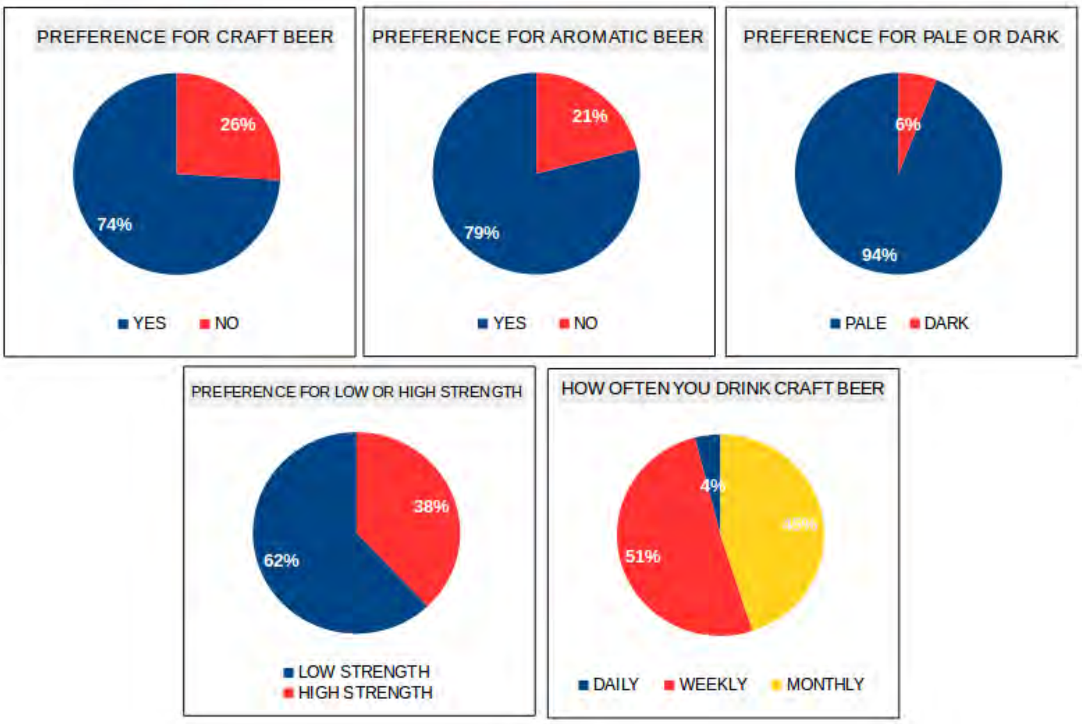


Figura 39. Pesquisa de Mercado do projeto de 2016.

Conforme mencionado anteriormente, uma pesquisa de mercado precisa ser desenvolvida pelos times. Esta pesquisa é importante, uma vez que analisando os resultados destas pesquisas foi possível definir as estratégias que os times devem seguir. Estas pesquisas contêm algumas questões interessantes sobre as preferências do tipo de cerveja, sabor, cor, teor de álcool e frequência de consumo do produto. A figura 01 mostra os resultados da pesquisa realizada por um dos grupos do projeto de 2016.

2.3 Desenvolvimento do Tipo de Cerveja

O processo de seleção de cervejas leva em conta os levantamentos e resultados apresentados pela pesquisa de mercado e realmente refletem a característica do consumidor brasileiro de cerveja. Os dois tipos de cerveja que normalmente mais agradam ao público-alvo são os tipos Pilsen e Wheat, que juntos representam cerca de 90% do consumo no mercado brasileiro de cerveja artesanal. Esta informação é utilizada para a escolha do tipo de cerveja a ser fabricada. Um dos times definiu, por exemplo, uma cerveja Witbier (branco belga) com uma característica esbranquiçada devido a levedura e trigo em suspensão. Este tipo de cerveja tem um toque cítrico de laranja, uma vez que a casca do fruto e a semente de coentro utilizados como complemento ao lúpulo.

2.4 Desenvolvimento da Marca

Após as tarefas técnicas, foi a hora de deixar a criatividade fluir e cada equipe auxiliada pela disciplina de Gestão de Negócios desenvolveram seu próprio logotipo e a identidade de seus produtos, criando um slogan para sua empresa. Os rótulos desenvolvidos pelos times são apresentados na figura 2:

Figura 2. Rótulos desenvolvidos pelos estudantes do projeto de 2016.

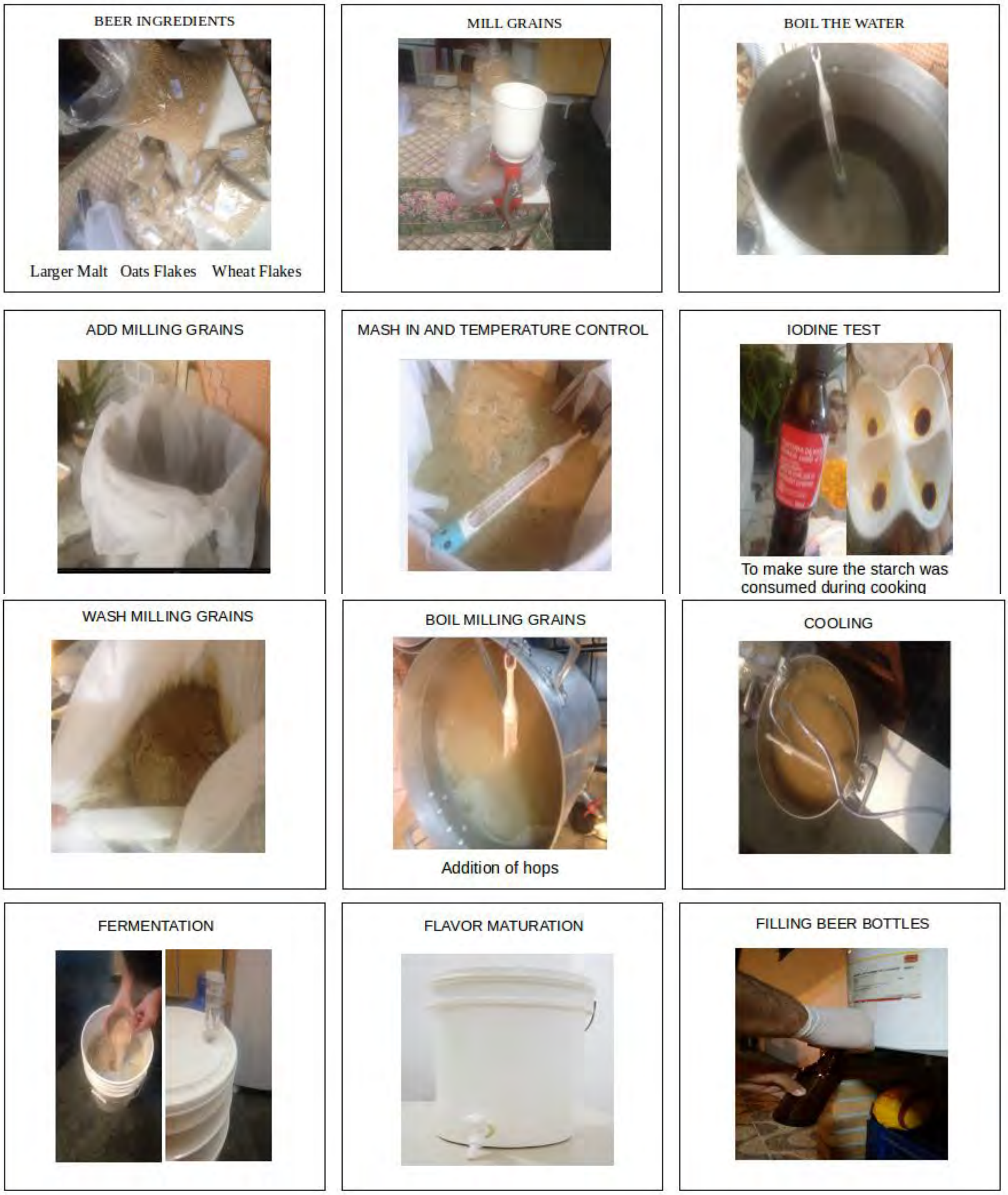
2.5 Desenvolvimento e Aquisição dos Equipamentos

A definição e aquisição dos equipamentos são realizadas de forma simples: através da web. Um dos times, por exemplo, decidiu comprar um kit com uma capacidade máxima de 12 litros para cada receita. Com base nos levantamentos de campo, eles sabiam que a capacidade desse equipamento atenderia às necessidades iniciais de fabricação.

2.6 Desenvolvimento da Matéria Prima e do Processo de Fabricação

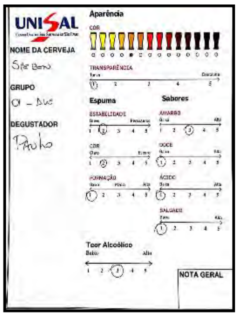
A fabricação de cerveja no mercado de cerveja artesanal é difere da produção industrial em grande escala, ou seja, pode-se dizer que na fabricação caseira, as técnicas utilizadas são mais simples e os equipamentos, não necessariamente, precisam ser modernos. Além disso, os ingredientes têm melhor qualidade e o controle do processo é menos rígido (Matos, 2011). Apesar desta afirmação, os controles de processo, especialmente a assepsia dos equipamentos, das garrafas e das tampas, são muito importantes para o sucesso dos produtos acabados. A figura 3 mostra a definição e execução do processo de fabricação apresentado por um dos times de estudantes.

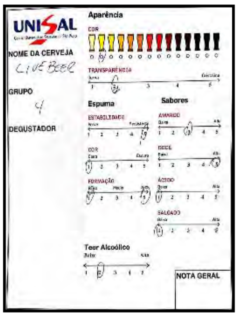
Figura 3. Fabricação de cerveja realizada pelos estudantes do projeto de 2016.



2.7 Avaliação da Qualidade

Com base nas necessidades de entrega foi criado pelos professores um teste de degustação para avaliar todas as cervejas. As folhas continham algumas informações sobre a qualidade do produto evidenciando suas características de aparência, espuma, sabores e teor de álcool, conforme demonstrado abaixo.





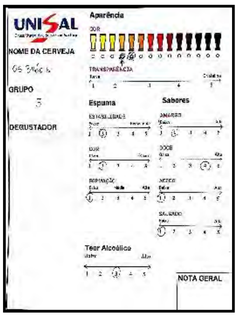


Figura 4. Fichas de degustação.

3 Discussões

O trabalho mostrou a realização de dois projetos interdisciplinares aplicados, o primeiro em 2016 e outro em 2017, no curso de Engenharia de Produção com o desenvolvimento e execução de um processo de fabricação tendo como produto final uma cerveja artesanal. Para estes projetos aplicou-se a interdisciplinaridade onde cada disciplina contribuiu para o desenvolvimento do projeto através do seu respectivo conteúdo programático, como evidenciado nas matrizes de contribuição das disciplinas, As disciplinas ao longo do curso de Engenharia de Produção do UNISAL tem características são fundamentais para a compreensão do processo de produção industrial real, abrangendo as diferentes áreas de uma empresa, sendo estruturante na formação do aluno, portanto, nosso projeto está de acordo com a orientação do curso e com o perfil de egresso exigido em termos de habilidades: análise qualitativa e quantitativa, comunicação, oportunidade, aprendizado, trabalho de grupo, contexto, design e diagnóstico.

Foi possível observar no projeto de 2016 benefícios nos aspectos de conhecimento, habilidades e comportamentos, mostrando mais uma vez sua importância em uma melhor formação de alunos para o mercado de trabalho. Isso é evidente através da análise de uma das soluções de engenharia propostas por uma das equipes, onde substituíram o aquecimento a gás, no processo da cerveja, por um resistor controlado por termostato melhorando o controle de temperatura do processo de fabricação. Já para o processo do refrigerante, a inovação de processo se mostra na utilização de uma embalagem alterativa, além do desenvolvimento de uma logística reversa. A inovação do mercado também é evidenciada em duas soluções para novos sabores de cerveja, uma das equipes fabricou cerveja de chocolate e outra usou o trigo fumado na fabricação de seu produto, desta forma, os times obtiveram sabores muito diferentes do que estamos habituados a ver e beber no mercado brasileiro, mas extremamente interessante em termos de inovação. Uma das dificuldades dos times no projeto é a aquisição dos equipamentos por ser oneroso para os estudantes, sendo assim, no projeto de 2017 alguns times optaram em fabricar seu próprio equipamento.

Os projetos mostraram benefícios no processo de aprendizagem, reduzindo a distância entre os conceitos teóricos com as práticas vivenciadas em empresas, mesmo tratando-se de um ambiente virtual. Também é possível observar benefícios nos aspectos de conhecimentos, habilidades e comportamentais, evidenciando, mais uma vez, a sua importância em uma melhor capacitação dos estudantes para o mercado de trabalho. Um dos resultados do projeto mostra que se deve executar um planejamento adequado com a capacidade de prever e propor situações reais do ambiente de trabalho em sala de aula. Isso pode permitir ao estudante a possibilidade de ingressar no campo profissional não apenas com algum conhecimento prático, mas também com algumas informações que vão além da atuação técnica, como por exemplo, gestão de tempo e de pessoas. Além disso, a adoção do modelo de aprendizagem centrado em projetos, com ênfase no aprendizado do aluno e seu papel ativo neste processo, consiste em uma metodologia que dá importância ao trabalho em equipe, à resolução de problemas interdisciplinares e à articulação da teoria e da prática que culmina na apresentação de uma situação real relacionada ao futuro profissional contexto.

As experiências apresentadas neste trabalho pretendem reforçar a importância desses projetos no processo ensino-aprendizagem da educação profissional para que o aluno entre em contato com situações reais do mundo do trabalho. No dia-a-dia das empresas, os indivíduos estão em constante desafio com novos problemas que se descortinam e precisam agregar conhecimentos adquiridos à capacidade proativa de buscar informações e tecnologias disponíveis. Além disso, precisam saber utilizar as habilidades necessárias ao desenvolvimento de um trabalho em grupo, tais como: saber ouvir, propor, reunir informações, mediar conflitos dentre outras, a fim chegar a um resultado satisfatório. A formação profissional dos indivíduos utilizando a pedagogia de projetos visa prepará-los para as pressões que envolvem a execução de tarefas empresariais corriqueiras. Além disso, a de produção de bebidas artesanais pode não só possibilitar a perspectiva do surgimento de novas cervejarias como negócio, mas também pode criar oportunidades para empresas relacionadas à oferta de matérias-primas e equipamentos, promovendo o empreendedorismo nos estudantes.

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Application of the Project Based Learning approach in the maintenance of aeronautical turbine accessories of General Eletric Aviation

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Abstract

This study integrates a more comprehensive research, called here a major research, whose central question is: How to apply the Project Based Learning (PBL) approach in a graduate course in production engineering? It presents the application of the initial model of the PBL approach in Production Engineering, proposed by the larger research, in one of the disciplines of the Synthesis and Integration content group that composes the backbone and conductive line of the Production Engineering training of the first undergraduate School of Engineering of Petrópolis, Universidade Federal Fluminense. The study aims to apply the PBL approach to propose an optimized flow of parts for the GE J85-21C Aeronautical Turbine Maintenance program processes. As for the research methodology, the study can be classified as a case study, in the review and service unit related to aeronautical engines of the company Avio do Brasil, controlled by GE Celma and both belonging to General Electric Aviation. Project Management practices, as suggested by the PMBOK Guide of the Project Management Institute (PMI), were used. The results obtained through concepts found in the literature, simulation and process mapping, interviews with employees and engineers of the organization, definition of the physical arrangement and a analysis of priorities based on tools such as Cause and Effect Diagram and the Analytic Hierarchy Process (AHP) , have confirmed the need to propose improvements in the layout for the prioritization of accessories and an optimized sequence, which take into account the various factors that permeate the flow of parts and can influence Turn Around Time (TAT) in a negative way.

Key-words: Active Learning, Production Engineering, Project Based Learning.

Aplicação da abordagem Project Based Learning na manutenção de acessórios de turbina aeronáutica da General Eletric Aviation

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Resumo

Esse estudo integra uma pesquisa mais abrangente, chamada aqui de pesquisa maior, cuja a questão central é: Como aplicar a abordagem Project Based Learning (PBL) em um curso de graduação de engenharia de produção? Ele apresenta a aplicação do modelo inicial da abordagem PBL em Engenharia de Produção, proposto pela pesquisa maior, numa das disciplinas do grupo de conteúdos Síntese e Integração que compõe a espinha dorsal e linha condutora da formação em Engenharia de Produção do primeiro curso de graduação da Escola de Engenharia de Petrópolis da Universidade Federal Fluminense. O estudo tem como objetivo aplicar a abordagem PBL para propor um fluxo otimizado de peças para os processos do programa de manutenção da turbina aeronáutica GE J85-21C. Quanto à metodologia de pesquisa, o estudo pode ser classificado como estudo de caso, na unidade de revisão e prestação de serviços relacionados a motores aeronáuticos da empresa Avio do Brasil, controlada pela GE Celma e, ambas pertencentes à General Electric Aviation. Utilizou-se as práticas de Gestão de Projetos, sugeridas pelo Guia PMBOK, do Project Management Institute (PMI). Os resultados obtidos através de conceitos encontrados na literatura, de simulação e mapeamento de processos, entrevistas com funcionários e engenheiros da organização, definição do arranjo físico e uma análise de prioridades baseada em ferramentas como Diagrama de Causa e Efeito e do método Analytic Hierarchy Process (AHP), confirmaram a necessidade de propor melhorias no layout para a priorização de acessórios e uma sequência otimizada, que levem em conta os diversos fatores que permeiam o fluxo das peças e podem influenciar de maneira negativa o Turn Around Time (TAT).

Palavras-chave: Aprendizagem Ativa; Engenharia de Produção; Aprendizagem Baseada em Projetos.

1 Introdução

O processo tradicional de ensino onde o conhecimento é transmitido ao aluno apenas pelo docente não atende mais às necessidades de mercado. O principal desafio da aprendizagem no terceiro milênio é formar profissionais com a competência de "aprender a aprender" (Bezerra, Costa & Riffel, 2010; Powell & Weenk, 2003). Para conquistar essa autonomia, o aluno precisa aprender a lidar com problemas reais e não apenas reproduzir soluções transmitidas pelo professor, utilizando metodologias ativas de aprendizagem.

O curso de Engenharia de Produção da Escola de Engenharia de Petrópolis utiliza a metodologia ativa "Aprendizagem Baseada em Projetos". A grade curricular do curso conta com cinco Projetos de Sistemas de Produção (PSP): Sistema de Produção, Projeto do Produto, Projeto do Processo, Planejamento e Controle da Produção e Inovação e Melhoria. A aplicação desta metodologia ativa intensifica e reforça a multidisciplinaridade característica da Engenharia de Produção, expondo o aluno à situações reais de diferentes dimensões e abrangências, onde o discente deixa de reproduzir para produzir o conhecimento.

Este estudo tem como objetivo aplicar a abordagem PBL para propor um fluxo otimizado de peças para os processos do programa de manutenção da turbina aeronáutica GE J85-21C. A organização parceira foi a Avio do Brasil, empresa controlada pela multinacional General Electric, dedicada à manutenção de turbinas aeronáuticas.Em paralelo a este projeto, foi realizada uma revisão de literatura acerca dos temas "aprendizagem baseada em projetos" e "sistemas de manutenção de turbinas aeronáuticas" com o objetivo de determinar quais aspectos devem ser considerados, que conceitos serão abordados e quais questões deverão ser respondidas para obtenção de embasamento teórico suficiente para propor soluções para a situação-problema definida pela organização.

Este estudo terá a seguinte estrutura: primeiramente, serão abordados os conceitos sobre manutenção de turbinas aeronauticas. Em seguida será apresentada a descrição da metodologia do projeto acadêmico em parceria com a Avio do Brasil. A seguir serão apresentadosos resultados obtidos, e finalmenteserão colocadas as conclusões e referências bibliográficas.

2 Manutenção de turbinas aeronáuticas

Branco Filho (2000) define manutenção como a combinação de todas as ações técnicas e administrativas, incluindo as de supervisão, destinadas a manter ou recolocar um item em um estado no qual possa desempenhar uma função requerida, sendo que item é qualquer parte, componente, dispositivo, subsistema, unidade funcional, equipamento ou sistema que possa ser considerado individualmente. Manutenção também pode ser definida como uma combinação de ações técnicas destinadas a preservar, conservar o estado dos equipamentos e componentes ou reparar um bem de um equipamento, para que os mesmos possam desempenhar bem as funções para as quais foi projetado.

Segundo Mello e Salles (2007), a evolução histórica da manutenção pode ser dividida em quatro fases ou gerações. A primeira fase iniciou a partir da Primeira Guerra Mundial, quando a manutenção tinha pouca importância nas indústrias e era considerada como secundária no processo produtivo. A segunda fase iniciou a partir da Segunda Guerra Mundial, com a necessidade de aumentar a produção e a sua rapidez, tendo assim um forte aumento na mecanização. Na terceira fase, entre 1940 e 1970, pode-se dizer que com o desenvolvimento da aviação comercial, houve uma expansão de critérios de manutenção preventiva. Essa fase é considerada a mais importante, pois a manutenção teve a possibilidade de se apresentar com uma maior qualidade, passando a ser vista como função mais qualificada. No início dos anos de 1970, surgiu a quarta fase, onde se acelerou o processo de mudança nas indústrias. A tendência mundial nessa época era utilizar o sistema "just-in-time", onde estoques reduzidos para a produção em andamento significavam pequenas pausas na produção que naquele momento poderiam paralisar a fábrica.

Os sistemas de manutenção podem ser classificados em quatro tipos: corretivo, preventivo, preditivo e lean. O sistema de manutenção corretiva ocorre quando é preciso atuar em equipamentos que apresentam um defeito ou que estejam operando fora do seu desempenho esperado. Essa atuação ocorre diretamente na parte que está ocorrendo a falha, podendo ser apenas reparos, alinhamentos, balanceamentos, substituição de peças e até mesmo a substituição do próprio equipamento. Deve ser observado que a manutenção corretiva tem como principal objetivo corrigir ou restaurar as condições de funcionamento do equipamento ou sistema (Pinto e Xavier, 2001).

Um sistema de manutenção preventiva consiste na intenção de reduzir ou evitar a avaria do equipamento. Para isso utiliza-se um plano antecipado, com intervalos de tempo definidos, independente da real necessidade, cujo objetivo será os cuidados preventivos que sejam de evitar as falhas (Kardec et al, 2003).

O sistema de manutenção preditiva é aquele que aponta para a realização de ajustes nas máquinas ou equipamentos apenas quando elas necessitam, porém sem que elas avariem ou parem. Pode ser definida como "aquela que indica as condições reais de funcionamento das máquinas com base em dados que informam o seu desgaste ou processo de degradação". (Marçal, 2004).

Já um sistema de manutenção lean pode ser definido como um sistema de manutenção proativo que utiliza atividades planejadas e calendarizadas, fundamentadas na Manutenção Produtiva Total (TPM), tendo como objetivo a gestão da carga de trabalho, redução do tempo de paragem dos equipamentos, garantia da eficácia do trabalho, aplicação de práticas que o otimizem e principalmente garantir a fiabilidade dos equipamentos.

A manutenção aeronáutica é "uma função logística dirigida ao material, no sentido de conservá-lo em condições de utilização ou de repará-lo, reconstituindo àquelas condições. A manutenção de aeronaves inclui não só a manutenção das aeronaves individualmente consideradas como um todo, mas também a manutenção dos órgãos ou componentes que as integram, mesmo quando delas separados” (Ribeiro, 2011).

Um sistema de manutenção de turbinas aeronáuticas consiste em um conjunto de processos que requerem tarefas, conhecimentos e procedimentos específicos que, agregados, têm o objetivo de identificar e reparar defeitos nas diversas estruturas de uma turbina aeronáutica, buscando assegurar que os componentes e equipamentos mantenham os seus níveis iniciais de segurança e fiabilidade, estando diretamente associado ao conceito de aeronavegabilidade, de segurança de voo e da prevenção de acidentes. Tais procedimentos incluem inspeções, reparações, revisões gerais, modificações e ensaios de funcionamento, devendo ser planejados e programados para possibilitar a utilização eficiente de recursos.

Neste tipo de manutenção, existe a constante necessidade de se combater a ocorrência do erro humano na execução da tarefa. Este é um fator decisivo para todo o sistema de manutenção de turbinas, pois uma aeronave, após a manutenção, não pode ser testada em uma bancada de testes e trata-se de uma indústria rigidamente regulamentada.

Os níveis onde ocorrem os serviços prestados pela organização são classificados em manutenção de linha, manutenção intermediária e manutenção profunda. A manutenção de linha consiste em uma inspeção visual que procura identificar as condições dos principais sistemas e componentes, sendo realizada no local de estacionamento da aeronave, permitindo ou não, de acordo com o resultado da inspeção, a próxima decolagem. A mantenção intermediária envolve atividades de inspeção e reparo de componentes de complexidade baixa e média, com tempos de imobilização prolongados e são realizadas em hangares, onde estão localizados recursos e equipamentos necessários para a execução das tarefas. Finalmente, a manutenção profunda corresponde às atividades de manutenção mais complexas, como grandes reparações, revisões gerais e modificações, com tempos longos de imobilização das aernovaves e realizadas também em hangares.

3 Metodologia

Esse estudo integra uma pesquisa mais abrangente, chamada aqui de pesquisa maior, cuja a questão central é: Como aplicar a abordagem Project Based Learning (PBL) em um curso de graduação de engenharia de produção?

A aplicação da abordagem PBL foi realizada na disciplina Projeto de Sistema de Produção I (PSP I) que está vinculada ao laboratório temático do Departamento de Engenharia de Produção, responsável pelas atividades de ensino, pesquisa e extensão relacionadas ao projeto, implantação, operação, avaliação e melhoria de sistemas de produção. A disciplina PSP I tem como objetivo desenvolver no aluno a habilidade de desenvolver projeto em grupo com solução integrada, envolvendo diferentes aspectos da Engenharia de Produção, relacionados ao desenvolvimento e gestão de sistemas de produção e operações sustentáveis e mais limpos.

Este estudo de caso foi realizado na empresa Avio do Brasil, controlada pela GE Celma, ambas pertencentes à General Electric Aviation. Primeiramente, a empresa formulou a seguinte situação problema: “Como otimizar o fluxo de peças no processo de manutenção da turbina aeronáutica GE J85-21C, de forma a assegurar o cumprimento do prazo estipulado em contrato com a FAB?”. Em seguida, os alunos planejaram e executaram três projetos para ajudar a solucionar a situação-problema proposta pela empresa.

Nos próximos itens são apresentadas a classificação da pesquisa, a determinação da unidade de análise do estudo, os procedimentos de coleta, avaliação e análise dos dados e as etapas de planejamento e execução do projeto.

3.1 Classificação da pesquisa

A pesquisa deste estudo classifica-se como estudo de caso que segundo Yin (2001) representa a estratégia mais adequada quando se colocam questões do tipo "como" e "por que", quando o pesquisador tem pouco controle sobre os eventos e quando o foco se encontra em fenômenos contemporâneos inseridos em algum contexto da vida real. Especificamente, pode-se classificar este estudo como estudo de caso exploratório, onde a equipe por meio de análise documental, entrevistas e observações teve possibilidade de aprofundar-senos problemas apresentados pela a organização parceira e então propor soluções.

3.2 Unidade de análise

A unidade de análise da pesquisa foi a empresa Avio do Brasil, controlada pela GE Celma e, ambas pertencentes à General Electric Aviation. A empresa é especializada em atividades de manutenção, assistência técnica e revisão de motores aeronáuticos sendo responsável pela revisão dos motores dos caças operados pela Força Aérea Brasileira. O foco do estudo foi no setor de acessórios da organização, pois este setorcontemas áreas com maior criticidade.

3.3 Procedimentos de coleta de dados

Os dados foram coletados em entrevistas com o diretor, o engenheiro de acessórios e os mecânicos que realizam o processo de manutenção de turbinas aeronáuticas. Também foram coletados dados em documentos e bancos de dados empresa, assim como em observações feitas pela equipe nas visitas técnicas semanais à organização.

Os princípios de coleta de dados preconizados por Yin (2001) foram aplicados no estudo e a equipe utilizou três fontes de evidências principais. As transcrições das entrevistas realizadas, os em relatórios das atividades e as informações coletadas em cada visita foram organizados em sequências lógicas de acordo com o cronograma do projeto para que o processo de identificação das propostas de melhorias pudesse ser progressivo e objetivo.

3.4 Procedimentos de avaliação e análise dos dados

Os procedimentos de avaliação e análise dos dados foram definidos em reuniões com a equipe da empresa e o professor da disciplina PSP I.

Na etapa de iniciação do projeto, foram realizadas reuniões para a coleta de requisitos do produto a ser entregue pela equipe. A seguir o grupo dividiu o produto em entregas, que consistem na rotina documentada, contendo simulação e mapeamento de processos, na análise da planilha de Tempos Padrões da Turbina J85 e na sequência otimizada, todas incluídas no Plano de Remoção de Acessórios.

Para a conclusão dessas entregas, os dados obtidos das diferentes fontes de evidências citadas anteriormente passaram por uma série de análises da equipe, com frequentes alinhamentos com o cliente e o focal point. Ferramentas como a Análise Hierárquica do Processo (AHP) e Diagrama de Causa e Efeito foram utilizadas para a avaliação dos dados obtidos.

A confiabilidade e validade das análises e avaliações de dados realizadas foram obtidas através da triangulação de dados, fundamento lógico, segundo Yin, para se utilizar várias fontes de evidências. O objetivo desta análise é chegar a um triângulo (ou diversas setas caso se tenha mais de três fontes de evidências) formado pelas três fontes de evidências que apontam para um mesmo fato observado. Essa técnica garante que coerência e convergência para as mesmas observações de diversas fontes.

Após os resultados encontrados, que podem ser vistos no item Resultados deste estudo, a equipe teve possibilidade de auxiliar na solução da situação-problema apresentada pela empresa.

3.5 Etapas da aplicação da abordagem PBL

Seguindo as boas práticas de Gestão de Projetos sugeridas pelo Guia PMBOK (PMI, 2013) a metodologia do projeto foi baseada nos processos que compõe o gerenciamento de projetos: iniciação, planejamento, execução, monitoramento e controle e encerramento.

3.5.1 1ª. Etapa – Definição da situação-problema e elaboração do termo de abertura do projeto

Na fase de iniciação, foram levantados os problemas que justificam o projeto e os objetivos a serem alcançados em reuniões com o cliente.

A partir dessas informações, o documento da Situação-Problema foi redigido. Em seguida, a partir da Situação-Problema, o Termo de Abertura foi consolidado, contendo os objetivos e justificativas, a descrição do produto e os benefícios alcançados pelo mesmo, os requisitos das partes interessadas, entre outras informações.

3.5.2 2ª. Etapa – Elaboração do plano de gerenciamento do projeto

Na etapa de planejamento, foi desenvolvido o plano de gerenciamento do projeto, que define como o projeto é executado, monitorado e controlado. A estrutura do plano foi uma apresentação do Project Canvas, ferramenta que fornece uma visão geral do projeto e foram definidos o gerenciamento do escopo, do tempo, das comunicações, das partes interessadas e dos riscos do projeto.

3.5.3 3ª. Etapa – Execução e controle do projeto

Na fase de execução e controle, as atividades planejadas foram realizadas em atividades semanais. As visitas eram realizadas às sextas-feiras, no turno da manhã, e a equipe era acompanhada integralmente pelo focal point, o qual permitia acesso às oficinas e setores, bem como à documentação necessária para o prosseguimento do estudo.

No início de cada visita, a gerente de projeto entregava ao focal point o cronograma do dia, contendo todas as atividades que deveriam ser realizadas, bem como a sua duração.

Também eram realizadas reuniões semanais da equipe com o patrocinador do projeto para o acompanhamento do projeto e esclarecimento de possíveis dúvidas.

3.5.4 4ª. Etapa – Encerramento do projeto

No encerramento do projeto houve a integração entre os planos das três equipes que realizaram o projeto na organização parceira para resultar em uma sequência ótima, promovendo uma visão abrangente de todos os processos da organização.

Foi realizada uma auto-avaliação e uma avaliação dos pares com os integrantes da equipe de modo a fornecer ao patrocinador do projeto e professor da disciplina PSPI critérios para atribuição de notas.

Finalmente, foi realizada uma apresentação pública do projeto com o objetivo de expor todas as atividades realizadas para a obtenção de resultados bem como com o intuito de entregar o Plano de Remoção de Acessórios para o cliente. A apresentação contou com a presença da diretora da UFF, do chefe de departamento e do coordenador do curso e também patrocinador do projeto, do diretor da organização parceira, bem como o engenheiro de acessórios e da engenheira de reparo. Alunos de outros semestres também estavam presentes.

4 Resultados

A seguir, são apresentados os resultados das atividades descritas no item 3 deste estudo.Este item foi estruturado em dois tópicos: análise da situação problema e propostas de melhoria.

4.1 Análise da situação-problema

4.1.1 Mapeamento do processo de reparo

O mapeamento de processos foi realizado em três níveis: O primeiro foi o SIPOC, que assegura uma visão ampla dos processos da empresa, desde o fornecedor ao cliente final. O segundo foi o fluxograma detalhado que apresenta um fluxo mais detalhado da organização, utilizando condicionantes; e em terceiro o fluxograma de tarefas que detalha, em nível de tarefas, os processos mais críticos para a etapa de remoção de acessórios.

4.1.2 Simulação de processos

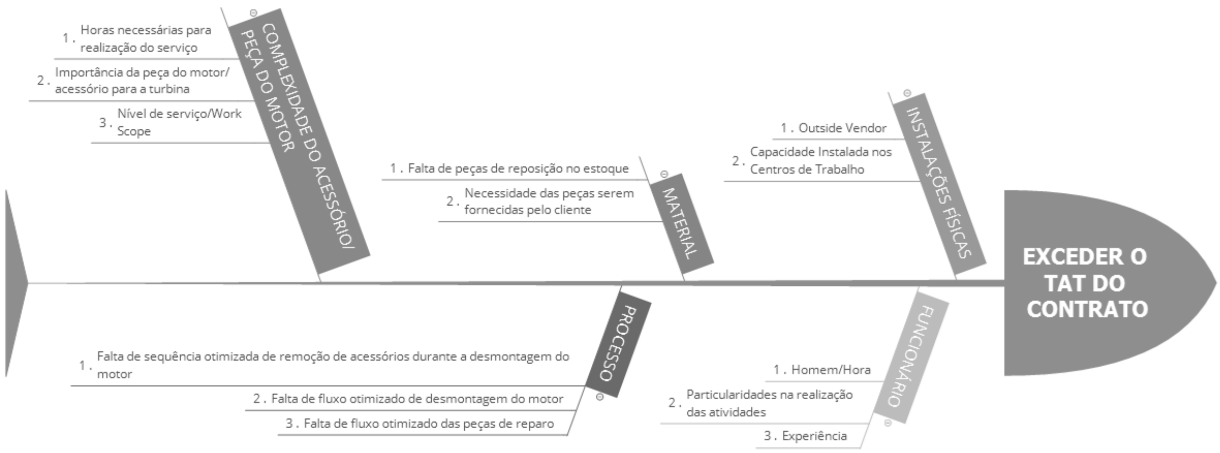
A simulação de processos consistiu em uma investigação em relação ao processo de remoção de acessórios para descobrir as oportunidades de melhoria na rotina atual da organização. Esta investigação é uma forma de se apontar as lacunas no processo de remoção de acessórios, bem como nos processos influenciados por ele.

O grupo realizou uma série de visitas ao chão de fábrica acompanhado pelo focal point com o objetivo de simular os processos desde a entrada do motor na organização até sua remontagem ao fim da manutenção realizada na Avio, tendo como foco o fluxo de acessórios, com suas atividades e setores. Nestas visitas foram realizadas entrevistas com os principais mecânicos. As perguntas tiveram como foco a ordem de remoção de acessórios preferida e/ou realizada por cada um.

4.1.3 Análise da planilha de Tempos Padrões de Acessórios da Turbina J85

A análise de prioridades utilizou como objeto a planilha de Tempos Padrões da Turbina J85, fornecida pelo focal point. A mesma enumera os acessórios da J85, os tempos padrões de cada um de acordo com o nível de serviço – inspeção e teste, reparo e revisão geral, bem como classifica em alto, médio e baixo a complexidade e os problemas com materiais de reposição. Esta análise teve como objetivo priorizar os vários critérios de avaliação para propor a sequência otimizada.
Para descobrir quais critérios avaliar, foi feito o diagrama de causa e efeito, também chamado de espinha de peixe. A especificação do problema colocada na cabeça da espinha de peixe é usada como ponto de partida para seguir a fonte do problema até a sua causa-raiz acionável.

Figura 1 – Diagrama de Causa e Efeito



As causas foram agrupadas nas seguintes áreas: complexidade do acessório, disponibilidade de material, processos, funcionários/fatores humanos e instalações físicas. Essas áreas foram utilizadas como os critérios para a análise de prioridades das mesmas. Para esta análise, foi utilizado o processo de análise hierárquica AHP (Analytic Hierarchy Process), que considera percepções, experiências, intuições e incertezas de modo racional, gerando escalas de prioridade ou pesos. Assim, através dessa ferramenta, pôde-se determinar qual critério é prioritário em relação aos outros.
Segundo o método, uma matriz de comparações foi elaborada de modo a atribuir notas que comparassem um critério ao outro. Essas notas foram atribuídas em função de reuniões e entrevistas com o focal point e mecânicos da organização. As notas seguiram o padrão de notas comparativas de Saaty (1991).

Tabela 1 – Matriz de comparações

MATRIZ DE COMPARAÇÕES - AHP					
	Material	Complexidade do Acessório	Funcionário	Instalações Físicas	Processo
Material	1	1/9	1/5	1/3	1/7
Complexidade do Acessório	9	1	9/5	9/3	9/7
Funcionário	5	5/9	1	5/3	5/7
Instalações Físicas	3	3/9	3/5	1	3/7
Processo	7	7/9	7/5	7/3	1

Analisando-se a matriz de comparações conclui-se que o critério a ser priorizado é a complexidade do acessório, seguido do processo, funcionário, instalações físicas e materiais.

Ao analisar a Tabela de Tempos Padrões de Acessórios da Turbina da J85, a equipe, com o auxílio do focal point, classificou os 41 acessórios da turbina J85 em três grupos em ordem de maior complexidade e horas trabalhadas: acessórios da Gear Box (caixa de engrenagens que possui acessórios acoplados a ela), bicos injetores e de parte externa.

4.2 Propostas de melhoria

4.2.1 Oportunidades de melhorias identificadas

Após a realização de todas as atividades descritas na Metodologia, foi possível apontar as seguintes oportunidades de melhoria no fluxo e no layout da organização:

- A checagem de PN (Part Nunber, "sobrenome da peça") e SN (Serie Number, "nome da peça") são realizadas tanto na Inspeção Preliminar quanto na Triagem, gerando retrabalho, já que como na Inspeção Preliminar muitas vezes não é possível visualizar o PN e/ou o SN, pois nesta etapa o motor ainda não foi desmontado, sendo necessária a conferência na etapa de Triagem, quando os acessórios já foram removidos.
- Existe uma falta de uniformidade na maneira como cada mecânico remove os acessórios. Habitualmente são removidos primeiro os acessórios de parte externa, que possuem em sua maioria, uma complexidade menor e problemas com material e horas trabalhadas baixas. Em seguida, a Gearbox é removida e somente após desmodularem completamente o motor é que os acessórios da Gearbox são removidos, sendo que estas etapas poderiam ser feitas simultaneamente. Por último, os bicos injetores são retirados e alguns deles necessitam de outside vendor (reparos fora da Avio do Brasil) e caso fossem removidos antes o procedimento seria agilizado.
- No setor de Limpeza e Ensaio Não Destrutivo, os acessórios permanecem juntos com as peças de motor em uma mesma estante denominada "Prioridades do Dia", que armazena as peças e acessórios que precisam de serviço em determinado dia. Por conta disto a preferência de escolha fica a critério do funcionário e comumente o motor é priorizado.

4.2.2 Propostas de melhorias apresentadas

4.2.2.1 Checagem de PN e SN na etapa de Triagem

Realizar a checagem de PN e SN somente na etapa de Triagem, evitando o retrabalho já que atualmente essa checagem é feita primeiramente na Inspeção Preliminar, ou seja, antes da Remoção de Acessórios e Desmontagem do Motor, e depois é conferida na Triagem.

4.2.2.2 Definição do workscope antes da Remoção de Acessórios

De acordo com os processos do sistema de manutenção de turbinas da Avio do Brasil, a definição de serviço ou workscope é realizada na etapa de Triagem, após a Remoção de Acessórios. Entretanto, o serviço definido só pode ser iniciado após a assinatura do workscope pelo cliente, que vai à empresa apenas duas vezes por semana.

Para evitar esse desperdício de tempo, a proposta de melhoria consiste em definir o nível de serviço do acessório antes mesmo da Inspeção Preliminar, pois as Fichas Históricas viabilizam a determinação do workscope antes do acessório ser removido e passar pela a etapa de Triagem. Com isso, ao ser removido e desmontado, as peças do acessório podem seguir imediatamente para os processos necessários para a finalização do nível de serviço definido, os quais podem ser Inspeção e Teste, Reparo ou Revisão Geral.

4.2.2.3 Sequência otimizada para o fluxo de remoção de acessórios

Agregando informações acerca das oportunidades de melhoria encontradas na rotina através de simulações e mapeamento de processos, bem como utilizando a análise de prioridades e a aplicando na planilha de Tempos Padrões de Acessórios da J85, os 41 acessórios foram separados em três grupos de prioridade.

Tabela 2 – Agrupamento de acessórios da J85

GRUPO 1	GRUPO 2	GRUPO 3
Main Fuel Control (MFC)	A/B Igniter Lead	Pressure & Drain Valve
Ven Power Unit (VPU)	Fuel Manifold	Ignition Exciter
A/B Fuel Control (ABFC)	A/B Main Spraybar	Overboard Bleed Air Valve
Lube & Scavenge Pump	A/B Pilot Spraybar	Tachometer Generator
Over Speed Governor	Fuel Nozzle	Oil Tank
A/B Fuel Pump (ABFP)	Thermocouple Harness - LH	Leakage Air Valve
T5 Motor	Thermocouple Harness - RH	Oil Filter
Main Fuel Pump (MFP)	VG Actuator	High Pressure Filter
Oil Cooler	Anti-Icing Valve	Electrical Cable
T2 Sensor & Linkage Assy		Main Igniter Lead
Hidraulic Oil Cooler		Nozzle Transmiter Position
A/B Drain Valve		Electrical Cable
Hydraulic Oil Filter		RTD Sensor
		Oil Tank Reliefe Valve
		Thermocouple Lead
		Pressure Switch
		A/B Igniter Plug
		Junction Box
		Main Igniter Plug

Os acessórios da Gearbox merecem prioridade devido à alta complexidade e ao maior tempo de execução do serviço Revisão Geral, estando presentes no Grupo 1. O Grupo 2 é composto pelos bicos injetores, bem como os acessórios que impossibilitam sua remoção, devido ao fato de que possuem média complexidade. Também encontram-se no Grupo 2, o VG Actuator e Anti-IcingValve, devido ao fato de que possuem média complexidade apesar de serem acessórios de parte externa. Por último, no Grupo 3, encontram-se o restante dos acessórios de parte externa, que possuem em sua maioria baixa complexidade e poucas horas de execução de serviço.

É fundamental que após a remoção da Gearbox, os acessórios acoplados a mesma sejam removidos imediatamente ao mesmo tempo em que os bicos injetores são removidos do motor.

Conforme os acessórios da Gearbox forem removidos, devem ser enviados imediatamente para a Desmontagem e seguirem para a Limpeza, considerando que o workscope já foi pré-definido antes mesmo da etapa de Remoção de Acessórios ser iniciada.

A sequência otimizada para o fluxo de remoção de acessórios é apresentada a seguir.

Tabela 3 – Sequência otimizada para o fluxo de remoção de acessórios

Ordem	Acessório	Ordem	Acessório
1	Main Fuel Control (MFC)	22	Anti-Icing Valve
2	Ven Power Unit (VPU)	23	Pressure & Drain Valve
3	A/B Fuel Control (ABFC)	24	Ignition Exciter
4	Lube & Scavenge Pump	25	Overboard Bleed Air Valve
5	Over Speed Governor	26	Tachometer Generator
6	A/B Fuel Pump (ABFP)	27	Oil Tank
7	T5 Motor	28	Leakage Air Valve
8	Main Fuel Pump (MFP)	29	Oil Filter
9	Oil Cooler	30	High Pressure Filter
10	T2 Sensor & Linkage Assy	31	Electrical Cable
11	Hidraulic Oil Cooler	32	Main Igniter Lead
12	A/B Drain Valve	33	Nozzle Transmiter Position
13	Hydraulic Oil Filter	34	Electrical Cable
14	A/B Igniter Lead	35	RTD Sensor
15	Fuel Manifold	36	Oil Tank Reliefe Valve
16	A/B Main Spraybar	37	Thermocouple Lead
17	A/B Pilot Spraybar	38	Pressure Switch
18	Fuel Nozzle	39	A/B Igniter Plug
19	Thermocouple Harness - LH	40	Junction Box
20	Thermocouple Harness - RH	41	Main Igniter Plug
21	VG Actuator		

Legenda	Acessórios da Gearbox
	Bicos Injetores e acessórios de influência
	Acessórios de Parte Externa

4.2.2.4 Melhorias de Arranjo Físico

A oportunidade de melhoria consiste na adoção de uma estante exclusiva para peças de acessórios, de modo a possuírem um local específico no setor de Limpeza e Ensaio Não Destrutivo que permita ao funcionário responsável por acessórios identificar visualmente e agir imediatamente, priorizando e realizando o serviço em acessórios devido ao baixo volume e simplicidade em relação às peças do motor.

5 Conclusão

O presente artigo teve como o objetivo aplicar a abordagem PBL para propor um fluxo otimizado de peças para os processos do programa de manutenção da turbina aeronáutica GE J85-21C. Os resultados obtidos revelaram que a prioridade deveria ser concedida ao grupo de acessórios acoplado à Gear Box, seguida dos bicos injetores e por último aos acessórios da parte externa. Com isso, foi proposta uma sequência otimizada de remoção de acessórios da turbina aeronáutica J85, bem como uma proposta de melhoria de arranjo físico com a estante exclusiva para acessórios.

A adoção da sequência otimizada para o fluxo de remoção de acessórios irá tornar o sistema de manutenção da Avio do Brasil, bem como seus processos e atividades, mais robustos, organizados e otimizados.

De acordo com informações fornecidas pelo cliente e pelo focal point, apesar de existir uma planilha determinando o tempo padrão de um acessório, geralmente deve-se considerar cerca do dobro do tempo para a execução do serviço, pois se leva em consideração toda a logística de transporte e movimentação das peças de acessórios entre as oficinas. Conjuntamente com as melhorias de checagem de PN e SN apenas na Triagem e definição do workscope antes da Inspeção Preliminar, espera-se que a sequência otimizada irá reduzir esse tempo total para execução do serviço.

Em relação à proposta de melhoria de leiaute, a adoção da estante exclusiva para peças de acessórios irá assegurar que o TAT do acessório não aumente devido à priorização para a realização de serviços em peças do motor, as quais são mais complexas e de maior volume.

O projeto acadêmico realizado na Avio do Brasil despertou competências e habilidades nos integrantes da equipe, reforçando a necessidade de metodologias ativas como o PBL em instituições de ensino superior de modo a formarem profissionais ativos que sejam responsivos às mudanças de mercado. Seria importante, para agregar valor às propostas de melhoria apresentadas, fazer futuramente uma integração ainda mais sólida dos produtos das três equipes de forma que todas as soluções atingissem ainda mais aos objetivos da organização.

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Interdisciplinary Active Learning by an event of technology in English as an opportunity for empowerment and new possibilities

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Abstract

This work aimed at contributing for the comprehension of contents by higher education students of Mechanical Technology – Welding Processes, in two disciplines, Non-Destructive Testing (Core area) and English (Human Sciences area, English I, II, and III), via an interdisciplinary activity using active learning. We had the opportunity of a presentation in English by an international sales representative about a NDT simulation software, and we started preparing to turn it into an educational experience. About sixty students, three professors, one of them the course coordinator, were involved in a collective project to welcome the company. We conducted a technical preparation using a material previously sent by the company representative, and it was explored in flipped classroom, considering vocabulary building and conceptual review in the disciplines of engineering and languages. The goal was the further interaction and free communication with the presenter about issues of specialized nature. The results were collected via participant observation, inputs for interaction, spontaneous reports/assessments and post-event discussions. For the technology discipline, we can consider that well instructed the students moved a step ahead to understand the company proposal and the unique NDT simulation software. For the language discipline, it was possible to overcome the limiting beliefs on the impossibility of communication, what empowered the students face to a real event, in free and dynamic negotiation of meanings. We conclude this experience is according to active learning, which considers the quality of interactions, fosters the initiative and leads to the future with a new view. We believe similar experiences can also be conducted with other disciplines of the engineering curriculum.

Keywords: Active Learning; Engineering Education; Interdisciplinary.

Aprendizagem ativa interdisciplinar em um evento de tecnologia em inglês como meio de empoderamento e despertar de novas possibilidades

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Resumo

O objetivo do trabalho foi promover a compreensão de conteúdos dos alunos do Curso Superior de Tecnologia em Mecânica: Processos de Soldagem, em duas disciplinas, de Ensaios Não Destrutivos, da área profissionalizante da engenharia mecânica, e disciplinas de Inglês (Inglês I, II e III, da área de ciências humanas), por meio de atividade interdisciplinar com aprendizagem ativa (*active learning*). Com a oportunidade de uma palestra em inglês de um representante comercial estrangeiro sobre um software de simulação computacional de ensaios não-destrutivos, iniciou-se a preparação para transformá-la em uma experiência educativa. Cerca de sessenta alunos, três professores, dentre eles o coordenador de curso, estiveram envolvidos em um projeto coletivo para receber a empresa. Realizou-se uma preparação técnica, com material previamente enviado pelo palestrante e trabalhado via *flipped classroom* com exploração vocabular/conceitual nas áreas de inglês e engenharia, para posterior interação/comunicação livre com o palestrante sobre assuntos de natureza especializada. Os resultados foram obtidos por meio de observação participante, estímulo à interação, avaliações espontâneas e depoimentos pós-evento. No caso da disciplina de tecnologia, já bem repertoriados, os alunos deram um passo à frente no entendimento da proposta da empresa e do funcionamento de um exclusivo software de simulação de NDT (*Non-Destructive Testing*), além de se instruírem teórica e amplamente sobre o tema. No caso de Inglês, houve quebra da crença na impossibilidade de comunicação e empoderamento dos sujeitos frente a um evento real, em franca e dinâmica negociação de sentidos. Concluiu-se que experiência realizada está de acordo com a aprendizagem ativa, que prima pela qualidade das interações, desperta a iniciativa e conduz ao futuro com nova bagagem, podendo ser realizada também com outras disciplinas, em outros cursos de engenharia.

Palavras-chave: Aprendizagem Ativa; Educação em Engenharia e Tecnologia; Interdisciplinaridade.

1 Introdução

A Faculdade de Tecnologia de Itaquera Prof. Miguel Reale (Fatec Itaquera) é uma das 68 unidades de ensino superior do Centro Estadual de Educação Tecnológica Paula Souza (CEETEPS), autarquia do governo estadual de São Paulo, que administra também mais 220 ETECs, escolas técnicas de ensino gratuito. Inaugurada em 2013, a Fatec Itaquera oferece quatro cursos superiores na área industrial: Fabricação Mecânica, Mecânica: Processos de Soldagem, Automação Industrial e Refrigeração, Ventilação e Ar Condicionado (REVAC).

Um de seus cursos, o de Tecnologia em Mecânica: Processos de Soldagem, conta com disciplinas básicas e profissionalizantes, onde o aluno deve, em seis semestres de formação, adquirir competências e habilidades que favoreçam sua entrada em um mercado de trabalho globalizado, dinâmico e competitivo.

Os alunos atendidos por essa unidade são, em sua maioria, trabalhadores, do sexo masculino, sendo muitos já pais de família, oriundos de bairros menos favorecidos da Zona Leste do município de São Paulo e arredores, quase em sua totalidade egressos de escola pública, alguns deles há muito tempo sem acesso a estudo formal ou com grande intervalo entre um período de formação e outro.

Ainda característico deste público é o grande número de alunos egressos de cursos profissionalizantes de formação de mão-de-obra qualificada, como SENAI, e que trabalham em funções técnicas operacionais. Isso redunda em uma identidade operacional bastante forte, cuja ideologia deve ser trabalhada para a promoção de um empoderamento – não só técnico, mas psicológico - para poderem ocupar funções gestoras no setor produtivo e de liderança de equipes em gestão de projetos. Um verdadeiro desafio para o corpo docente: trabalhar a formação ética e humanística integrada a conceitos técnico-científicos em constante modernização.

No Centro Paula Souza, por opção curricular, o inglês é ministrado via abordagem comunicativa, considerando os alunos como "*false beginners*", com o uso de material de *Business English*. Para este curso, são oferecidos três semestres com aulas semanais, o que corresponde a disciplinas de inglês ministradas em metade de sua formação acadêmica. Mesmo assim, os alunos apresentam dificuldades para compreender, comunicar-se e sair do patamar básico. Ainda que muito mais seja necessário fazer, tal carga horária destaca-se em cursos de tecnologia, os quais em sua maioria não têm inglês em sua grade curricular.

O domínio de línguas estrangeiras é uma competência transversal, isto é, que faz parte de competências técnicas interdisciplinares e habilidades de comunicação e gerenciamento. Ela é tão importante que chega a ser mais exigida no mercado de trabalho do que outras competências transversais, como domínio de tecnologias de informação e comunicação, capacidade de trabalho em equipe, comunicação, liderança, planejamento & organização, iniciativa, visão estratégica, autoconfiança, maturidade e ética (Lima, Rocha, Mesquita & Rabello, 2017).

O aprendizado de uma língua estrangeira exige a quebra de crenças e barreiras pessoais. Não basta disponibilizar uma ou mais disciplinas de língua estrangeira na grade curricular de um curso de graduação focado mais no saber técnico (*hard skills*) do que no saber estar (*soft skills*) (Simão, 2002). Neste sentido, as metodologias de aprendizagem ativa (Johnson et al. 1991), traduzidas em atividades cooperativas e participativas, em um ambiente adequado ao desenvolvimento de capacidades e competências transversais, são propícias para aplicação.

Para que as competências transversais sejam desenvolvidas, é necessário haver também, além de um ambiente adequado, o envolvimento da coordenação, dos docentes e dos alunos (Carvalho e Lima, 2006), em cursos de graduação em engenharia ou tecnologia. E também é fundamental o elo da educação com a experiência, esta última entendida não somente como aspecto prático ou vivenciado, ou ainda somente agradável de se fazer e ver ou, ao contrário, de todo desagradável. É justamente a *qualidade* da experiência e seus reflexos posteriores que podem levar ao conhecimento de fato e, principalmente, à mudança de postura em relação a ele. Consequentemente, também em relação a outras experiências que se sucederão (DEWEY, 1979, p.16). A linha deweyana, precursora de muitas correntes educacionais de ensino ativo, permite trazer de volta a vida à escola, na forma de ação dos alunos e de seu conflito saudável durante o aprender, sem deixar de lado toda parcela de incômodo, dor e readaptação que o processo envolve.

Neste contexto, este trabalho teve como objetivos apresentar uma tecnologia pouco conhecida na área de uma disciplina técnica do curso (*hard skill*) em inglês (*soft skill*), mostrando a importância do domínio de línguas estrangeiras no mundo globalizado e derrubar a barreira da sensação de incomunicabilidade que os alunos demonstravam em sala de aula. Esperava-se, como resultado, motivá-los a terem uma atitude mais ativa e menos passiva para aquisição de novos conhecimentos nas disciplinas envolvidas. Um pressuposto teórico norteador desta iniciativa é a interdisciplinaridade como uma "totalização em construção", que respeita os fragmentos dos saberes, mas estabelece por meio de experimentações uma relação entre eles, visando sua ampliação em uma busca dinâmica (Gadotti, 1999, p. 4).

2 Materiais e métodos

Utilizou-se a pesquisa-ação, que é um método de pesquisa empírica aplicável em situações onde há interdisciplinaridade e envolvimento dos pesquisados (Macke, 1999). As principais etapas dessa metodologia são: compreensão do problema (fase exploratória); priorização dos problemas, busca de soluções, planejamento de ações (fase principal); e aprendizagem dos participantes (fase de ação, seguida da fase de avaliação).

Uma palestra de uma empresa internacional, líder em soluções de software de simulação de Ensaios Não Destrutivos (END), foi o mote para se promover o ensino compartilhado da disciplina técnica chamada Tópicos Especiais de Soldagem III (*hard skill*), cujo conteúdo se refere a ensaios não destrutivos realizados na área de mecânica, e de Inglês (*soft skill*), na FATEC Itaquera.

Os ENDs consistem em métodos empregados para a avaliação de propriedades e atributos de materiais, que podem ser realizados em matérias-primas, produtos semiacabados ou acabados, com a importante característica de não destruir ou causar qualquer tipo de comprometimento à utilização futura dos mesmos. Por essas características, a área dos ENDs, embora seja técnica, possui caráter fortemente transversal. Além de envolver conhecimentos técnicos, relaciona-se a análise econômica, melhoria contínua, qualidade, comunicação e treinamento de pessoas, sendo, portanto, o contexto adequado para a integração e consolidação de conteúdos multidisciplinares. Para completar, a oferta de literatura específica e de trabalhos publicados em língua portuguesa nesta área é relativamente escassa, sendo indispensável a habilidade de leitura em idioma estrangeiro para quem deseja entender o assunto ou mesmo nele se especializar.

A ideia era apresentar aos alunos um moderno software de simulação de END por algoritmos computacionais, que dispensa o uso de equipamentos eletrônicos físicos, que custam caro e requerem materiais de consumo. Tais ferramentas de software ainda são pouco conhecidas no país, embora sejam amplamente utilizadas em países desenvolvidos, tendo a língua inglesa como interface de operação.

No evento, a apresentação do software seria realizada por um representante comercial da França, somente em inglês, profissional este que dá treinamentos a empresas que adquirem o produto. Junto com a coordenação de curso, os professores da disciplina técnica e de inglês realizaram, então, um trabalho conjunto de preparação dos alunos para viabilizar tal apresentação.

Para fins de preparação conceitual, o professor da disciplina de ENDs adequou o material didático utilizado no curso, utilizando-se da apresentação em inglês cedida antecipadamente pela empresa. O plano de aula da disciplina técnica é composto por dezessete tópicos - dentre os quais, ensaio visual, por líquido penetrante, por partículas magnéticas, por correntes parasitas, por ultrassom e radiografia, dentre outros. Aproximadamente 45% do plano de aula consistiu em informações que foram abordadas direta ou indiretamente na palestra da empresa. Além da parte conceitual, aos alunos foi esclarecida a importância da simulação computacional associada à tecnologia dos ENDs e as possíveis oportunidades que o conhecimento dessa ferramenta pode proporcionar ao futuro profissional e acadêmico do tecnólogo em mecânica.

Os slides utilizados em sala-de-aula aula (figura 1) passaram a incorporar a tradução de palavras e expressões-chave. Foram também incorporados vídeos de apoio, consulta a catálogos e distribuição de pequenos textos para estudo complementar, todos em inglês.

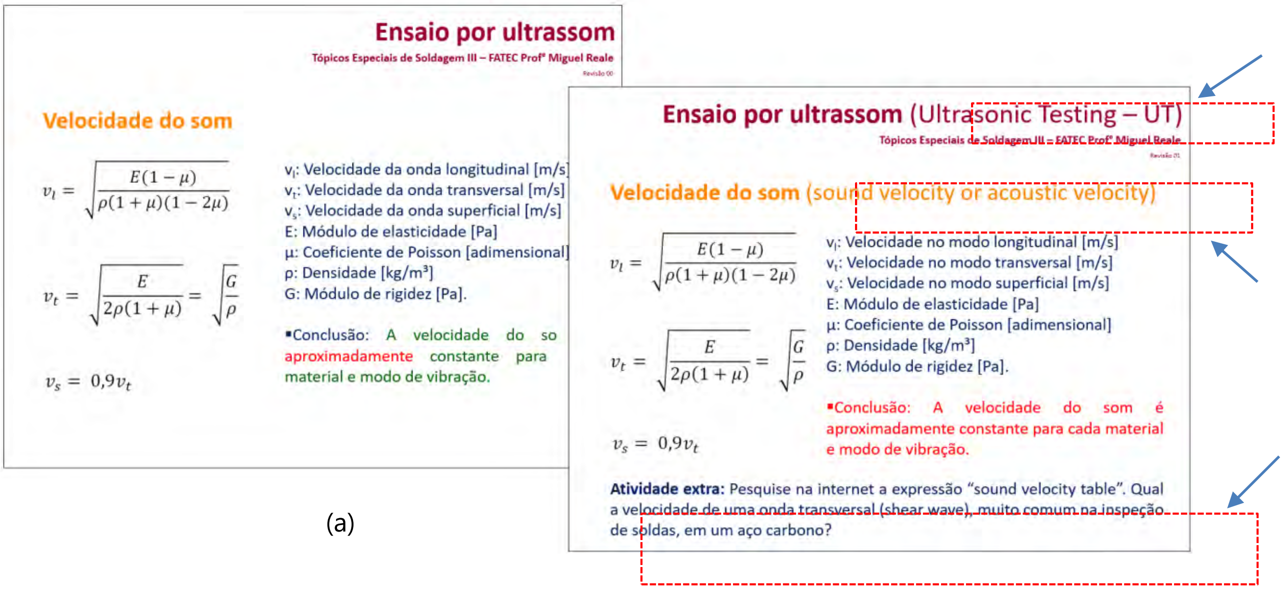

Figura 4 – Exemplo de slide de aula utilizado no curso de END (a) antes e (b) após o início do projeto. O material de apoio às aulas passou a incorporar elementos para estimular o contato com a língua estrangeira, aqui destacados.

Repertoriados tecnicamente, os alunos supostamente estariam preparados para acompanhar a exposição em inglês, fazendo, por fim, perguntas pertinentes à sua área de formação e interesse.

O trabalho com o material cedido pela empresa na disciplina de Inglês foi feito inicialmente com técnicas de ensino de ESP (*English for Specific Purposes* – Inglês para Fins Específicos), no sentido de repertoriar mais rapidamente os alunos quanto ao vocabulário a que teriam de mobilizar para a necessidade em vista. Entretanto, não se entenda isso como apenas o estudo estrito de terminologia específica em abordagem apenas para fins de leitura e compreensão. De acordo com Vian (1999, p. 429) em revisão sobre o tema:

> O termo inglês instrumental é parte de um movimento maior na área de ensino de línguas estrangeiras denominado língua para fins específicos (Language for Specific Purposes - LSP), no qual se insere o ensino de qualquer língua estrangeira com foco nas necessidades específicas do aprendiz, objetivando o uso da língua-alvo para desempenho de tarefas comunicativas, sejam elas de produção ou compreensão oral ou escrita naquela língua.

No trabalho em sala de aula, houve o envolvimento das quatro habilidades comunicativas. Uma oportunidade como tal justificou para os alunos a preparação em termos de leitura da parte técnico-conceitual (*reading*), produção escrita para posterior verbalização (*writing / speaking*) e o desafio da compreensão oral (*listening*).

Para dar conta de tal tarefa, aos alunos foi proposto o trabalho em grupo de: i) mapeamento dos termos técnicos relevantes e seu esclarecimento; ii) leitura e interpretação de fragmentos com exercícios sobre partes do conteúdo; iv) atividades de refrasear oralmente para checagem de entendimento e v) criação de possíveis perguntas em inglês sobre pontos tecnicamente obscuros ou questões do interesse de cada um dos grupos. Tais perguntas foram revisadas pelas docentes e devolutivas foram dadas aos alunos para reforçar sua bagagem discursiva e motivar seu desempenho para o momento da performance. Esses procedimentos foram realizados por meio de tarefas para casa e em trabalhos em grupo em sala, com supervisão docente, durante duas aulas. A parceria com a disciplina de Ensaios Não-destrutivos (ENDs) foi de fundamental importância para o tratamento do conteúdo altamente especializado abordado na apresentação.

O evento foi organizado em cinco momentos de exposição e interação: i) a abertura do evento e a chamada do palestrante com mini currículo; ii) uma fala breve sobre END, retomando conceitos essenciais; iii) uma segunda fala breve sobre a importância do inglês nessa área com tão pouca literatura em língua portuguesa; iv) a apresentação propriamente dita do software de END e v) o momento de plenária de perguntas e respostas com mediação e incentivo à interação discentes-palestrante.

A fase de avaliação foi realizada durante as aulas das duas disciplinas, após o evento, por meio de perguntas e respostas entre professores e alunos. Também foram feitas observações dos professores nas aulas que se seguiram durante o semestre em relação à participação e motivação dos alunos durante as aulas.

3 Resultados

A parte contextual técnica relacionada ao uso de ultrassom tinha sido tratada em sala de aula e o objetivo maior era ver o mesmo trabalho sendo apresentado em segunda língua. Muitas imagens de processos e resultados ilustravam o que às vezes o conteúdo poderia mascarar. O grau de compreensão pode até ser o maior desafio para se avaliar, mas a plenária trouxe resultados que se mostraram animadores, pois demonstrou a iniciativa dos alunos.

Ao mesmo tempo em que docentes e alunos se aquietaram para ouvir a apresentação de cerca de uma hora, os docentes continuaram seu trabalho de observadores participantes, atentos ao ambiente, ao conteúdo e aos momentos de interação.

Para quebrar a barreira da comunicação e o formalismo da situação, o coordenador iniciou chamando os alunos a reportarem o entendimento inicial e muitos se manifestaram trazendo detalhes do que tinham compreendido (ou não) e do que pensavam em perguntar. Em seguida, começaram a formular perguntas, em alguns momentos pedindo auxílio às docentes para que as revisassem, o que os deixou mais seguros para a participação ao vivo.

Após as perguntas técnicas que, de fato, já tinham sido aventadas como dúvidas em sala de aula, vieram perguntas de toda ordem, inclusive pessoais: como tinha sido o percurso de estudos do palestrante até chegar àquela área, como são realizados os estudos na França (local em que ele está radicado), como iniciou sua carreira até chegar a essa posição com viagens internacionais, que cursos fez, onde estudou e até mesmo como se faz para trabalhar na França. As perguntas começaram a sair do "momento ensaiado" para a "interação livre", o que de alguma forma é indicativo da espontaneidade e da autoconfiança forjada naquela interação.

Para efeito de organização, a cada réplica, intervenções do coordenador e das docentes de LE facilitavam a negociação de sentidos, a revisão do que tinha sido entendido, o que, de quebra, estimulava que os alunos reportassem seus ganhos e expusessem também seus *gaps* de comunicação.

No pós-evento, foram realizadas reuniões com os alunos para que opinassem livremente sobre o que tinham achado da experiência e foi solicitado que escrevessem, caso quisessem, uma avaliação do que pensaram da apresentação, do palestrante, do seu envolvimento, enfim, do que quer que tivesse chamado sua atenção sobre a experiência. Os resultados surpreenderam.

Na conversa em sala pós-evento, iniciaram-se os comentários que, ao que parecia, iriam contribuir pouco para o que se desejava saber. Por estarem à frente de um docente de inglês, dizer que "era importante" e "que tinha sido significativo para sua formação" pode ser visto como resultado de um discurso assimétrico, que motivaria respostas meramente convencionais. No entanto, estímulos das docentes e comentários pessoais delas sobre diversos aspectos, inclusive os gramaticais e de pronúncia do palestrante, dispararam comentários mais espontâneos que combinavam com o comportamento livre e espontâneo dos alunos no evento, ao fazerem perguntas.

Assim, mais tarde, foram colhidos comentários escritos como:

A experiência com o XX, na palestra sobre ultrassom foi muito boa. Pois eu entendi que não é necessário falar inglês fluente para se comunicar com as pessoas. (sic) (PRSC)
Percebi a importância da comunicação, seja feita com fluência ou não, o simples fato de entender e ser entendido mesmo que a forma gramatical não esteja correta. (sic) (RVG)
Foi percebido por mim a necessidade pessoal de se inteirar do assunto que será tratado em outra língua, principalmente quando for técnico, onde foram usadas palavras técnicas que não somos acostumados a escutar. (sic) (RVG)

O XX ficou despreocupado com a questão da pronuncia e se sentiu acolhido e contente com as perguntas mesmo que soube-se que muitos não falam inglês. Professores e docentes deram apoio e incentivos para nós. (sic) (LSL)
Por quê tanta vergonha de falar em público da maneira correta sendo que sou iniciante em inglês? (sic) (LSL)

Um aspecto linguístico que não pode deixar de ser lembrado é o fato de o palestrante ser filho de espanhóis, nascido e criado na França, trabalhando pelo mundo usando o inglês como idioma de comunicação. Estamos de fato trabalhando em segunda língua nos dois polos da comunicação – falante e ouvintes, o que altera muito a natureza da interação. Isso traz como resultado sotaques, palavras latinas que entram na negociação de sentidos, dúvidas sobre termos e momentos de hesitação de ambas as partes. Alguns alunos de pronto perceberam o forte acento francês a interferir na pronúncia do inglês, outros capitalizaram esse aspecto, tomando as palavras ditas afrancesadas como um recurso para o entendimento em português. Isso é hoje estudado cientificamente como intercompreensão entre línguas românicas (Sá, 2013), sendo alvo de estudos fecundos.

Alguns mitos também foram quebrados com essa experiência. O principal deles é a questão da fluência. Por exemplo, ver o palestrante hesitar, adaptar termos, trazer termos de outras línguas para ajudar os alunos ou organizar para si mesmo sua fala: tudo isso mostrou aos alunos a imprevisibilidade das interações verbais e o quanto se pode organizar, reorganizar e retrabalhar em situações ao vivo (Marcuschi, 1998, p. 27).

Outro aspecto relacionado ao anterior foi a correção no uso da língua. Com um público travado por sua baixa-estima, que por vezes duvida de sua capacidade de transitar em outro idioma ou no próprio ("se nem sei português, como vou aprender inglês?"), a experiência mostrou aos alunos que nem tudo é perfeito na fala em segunda língua e que errar e corrigir-se faz parte do processo de qualquer falante. Demonstrou que negociar sentidos até o entendimento é da natureza da comunicação viva e que tais elementos podem inclusive servir como interessante material para o estudo da cognição e da organização da fala e do pensamento (MARCUSCHI, 1998, p. 30).

Talvez pela própria natureza, com relação às metodologias ativas, o ensino comunicativo de inglês obrigatoriamente se vê adiante em relação a outras disciplinas, mesmo com todas as dificuldades e resistências que têm de enfrentar. Dinâmicas, jogos, simulações, dramatizações e o uso praticamente rotineiro de TICs colocam foco extremo na didática e no envolvimento dos alunos. Não há como ficar passivo em uma aula que impõe a participação e a produção em diferentes instâncias.

Mas o principal ganho da experiência veio da interação entre as áreas técnica e de linguagem. Estudando a motivação de alunos à luz das ideias deweyanas, Bernardino (2009, p. 4) aponta que esse autor já falava sobre o tão importante quanto vago conceito de "interesse dos alunos", com argumentos contra e a favor:

> Dewey, que já se ocupava dessas mesmas preocupações, em Vida e Educação (1954), apresenta duas teorias: uma favorável e outra contrária ao propósito de se despertar o interesse do aluno. Na defesa do interesse constata-se que é por meio dele que se garante a assimilação de conhecimento por parte do aluno.
>
> A argumentação contrária é a de que a vida não é permeada por apenas situações favoráveis e agradáveis. Há que se sujeitar, às vezes, às agruras da vida, empregando esforço contínuo para se formar o hábito e o caráter.

No entanto, a autora segue argumentando que "a identificação ou correspondência entre o objeto e o agente poderia ser uma possível solução para o problema motivacional em sala de aula" (BERNARDINO, 2009, p.4), algo que Dewey identificou como ponto cego entre as duas tendências.

Sendo assim, combinar o desafio da interação em segunda língua com um tema da área de estudo dos alunos pode ser visto como a possível explicação para a performance dos sujeitos, sua adesão, ao evento, suas tentativas e erros, além dos pedidos de ajuda para poder "fazer melhor". O resultado foi a autêntica e proveitosa comunicação presenciada entre todos.

4 CONCLUSÃO

Na concepção deste trabalho, para apresentar uma nova tecnologia a alunos do curso de Mecânica: Processos de Soldagem da Fatec Itaquera, um obstáculo precisava ser vencido: a falta de embasamento teórico de alunos para assistirem a uma apresentação técnica em língua estrangeira. Com a utilização de uma abordagem baseada em aprendizagem ativa e aprendizado baseado em problemas, alunos e professores trabalharam conjuntamente para aproveitar a chance e capitalizá-la como uma oportunidade pedagógica interdisciplinar.

A aprendizagem ativa ocorreu pela exposição dos alunos a materiais didáticos auxiliares relacionados à apresentação técnica que seria realizada. Os alunos puderam pesquisar sobre o assunto, tirar dúvidas com os professores e formular questões previamente para serem feitas na apresentação. O entendimento seria feito em tempo real, em interação autêntica em língua estrangeira, sem recurso de tradução.

A aplicação da aprendizagem baseada em problemas foi concretizada pelo desafio de professores e alunos compreenderem um assunto técnico (aprendizagem), em língua estrangeira (problema). Houve razoável compreensão do assunto e interação com o palestrante, o qual, inclusive, expôs sua experiência profissional em outros países não falantes da língua inglesa e motivou os alunos a tentarem se comunicar, mesmo sem dominar a língua com perfeição.

A avaliação foi realizada qualitativamente neste trabalho inicial, por meio de depoimentos escritos e orais, sem uso de técnicas de validação, sendo que para trabalhos futuros deverão ser utilizadas metodologias mais adequadas de avaliação.

Os resultados podem ser avaliados como satisfatórios do ponto de vista de aprendizado, motivação dos alunos e o principal, em ganho de autoconfiança, empoderamento, negociação comunicativa, quebra de crenças e mitos na comunicação em inglês.

Considera-se que a metodologia utilizada possa ser aplicada, com ajustes e melhorias, integrando diferentes disciplinas, em diferentes cursos. Espera-se que a experiência relatada neste trabalho tenha continuidade na Fatec Itaquera e sirva como ponto de partida para motivar outras instituições.

Do ponto de vista da coordenação, um resultado positivo foi a integração interdisciplinar, um ganho para todos os participantes, pois superou a multidisciplinaridade rumo a uma atitude interdisciplinar (Gadotti, 1999; Japiassu, 1976), entre os professores da disciplina técnica e de inglês. Como resultado, a performance dos alunos é sintomática da superação do conhecimento isolado em disciplinas.

Para a faculdade, um resultado positivo foi a promoção de um evento internacional em suas dependências, em horário de aula, sem despesas extras, com amplo envolvimento de alunos e professores. Professores de outras disciplinas assistiram a palestra e foram expostos a uma alternativa pedagógica que poderiam aplicar em suas aulas, além de conhecerem as potencialidades de um moderno recurso de software, o que enriquece seu repertório interdisciplinar.

Considera-se que a experiência foi bem-vinda para todos, alunos, professores, coordenação e direção, e trouxe resultados significativos, não somente em termos de conhecimento técnico, mas em relação à experiência acadêmica marcante vivenciada pelos alunos, que permitirá a recordação positiva sobre a maneira como puderam adquirir novos conhecimentos.

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Constrains and Challenges of learning experience with Problem Based Learning: a pilot study in the perception of students of the marketing discipline of the course of Administration of the Federal University of Rio Grande do Norte -UFRN

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Abstract

Problem-based learning contributes to the development of skills, knowledge, and attitudes in students, where the educational premise is that the skills required to apply analytical principles and techniques can be better learned if they are practiced in problem contexts, facilitating the the sciences as well as being a potential for the application of interdisciplinarity in the classroom. Although there has been progress in the use and attempts to adopt active teaching methodologies in Administration, such as PBL, Gaeta (2010); Roesch (2007) and Araújo, Rejowski and Leal (2012) emphasize that traditional methods still predominate in this transmission of knowledge. The objective of this work is to understand obstacles and challenges in students' perception of the learning experience with the Problem Based Learning - PBL methodology in the Marketing course of the Administration course of the Federal University of Rio Grande do Norte. The study is characterized as a case study of exploratory nature and qualitative approach, through the application of a semi-structured interview, with 11 students who studied the discipline, from the content analysis of the following theoretical categories: participation in the activity of the PBL; interaction of the group in the work and commitment of the students with the research activities. The results showed that, in general, the students evaluated the application of the methodology as positive, however, some obstacles were pointed out, in the posture of the students that compromise the development and the formation of skills and abilities, such as: unavailability of time for reading and research; overload of activities, in addition to the demands of the discipline, as impacting the involvement, commitment and participation of them in the process, besides customs and cultural habits rooted in traditional teaching methodologies, with frequent use of the division of tasks in the development of discipline activities and the lack of interaction and participation of the students, through the adoption of the group work and not in the team, noting also a lack of clarity and understanding of the need to change their posture in a discipline that adopts the PBL.

Keywords: Active Learning; teaching management; Problem Based Learning.

Entraves e desafios da experiência de aprendizagem com base em problemas: um estudo-piloto na percepção de estudantes da disciplina de Marketing do curso de Administração da Universidade Federal do Rio Grande no Norte – UFRN

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Abstract

O aprendizado baseado em problema contribui no desenvolvimento de habilidades, conhecimentos e atitudes nos estudantes, onde a premissa educacional é que as habilidades requeridas para aplicação de princípios e técnicas analíticas podem ser melhor aprendidas se praticadas em contextos problemas, facilitando também a vivência de relações entre as ciências, bem como, sendo um potencial para a aplicação da interdisciplinaridade na sala de aula. Apesar de ter havido um progresso quanto ao uso e de tentativas de adoção das metodologias de ensino ativas em Administração, como o PBL, Gaeta (2010); Roesch (2007) e Araújo, Rejowski e Leal (2012) destacam que ainda predominam métodos tradicionais nessa transmissão do conhecimento. O trabalho tem como objetivo compreender entraves e desafios na percepção de estudantes da experiência de aprendizagem com a metodologia Problem Based Learning – PBL na disciplina de Marketing do curso de Administração da Universidade Federal do Rio Grande do Norte. O estudo caracteriza-se como um estudo de caso de natureza exploratória e abordagem qualitativa, através da aplicação de uma entrevista semi-estruturada, com 11 alunos que cursaram a disciplina, a partir da análise de conteúdo das seguintes categorias teóricas: participação na atividade do PBL; interação do grupo no trabalho e comprometimento dos alunos com as atividades de pesquisa. Os resultados demonstraram que, de modo geral, os estudantes avaliaram a aplicação da metodologia, como positiva, apesar disso, foram apontados alguns obstáculos, na postura dos alunos que comprometem o desenvolvimento e a formação de competências e habilidades, tais como: indisponibilidade de tempo para a leitura e pesquisa; sobrecarga de atividades, além da carga de exigências da disciplina, como impactantes para o envolvimento, comprometimento e a participação deles no processo, além de costumes e hábitos culturais arraigados a metodologias tradicionais de ensino, com o uso frequente da divisão de tarefas no desenvolvimento das atividades da disciplina e da falta de interação e participação dos alunos, através da adoção do trabalho em grupo e não em equipe, percebendo-se ainda, uma falta de clareza e compreensão da necessidade de mudança de postura deles em uma disciplina que adota o PBL.

Keywords: Aprendizado ativo; ensino de administração; Aprendizado com base em problema.

1 Introdução

O Problem Based Learning - PBL é uma metodologia de ensino aprendizagem em que um problema é utilizado como início de discussão de um conceito ou conteúdo, posteriormente o docente faz um direcionamento do que é produzido pelos discentes em pequenos grupos, motivando-os a pesquisar (RIBEIRO & MIZUKAMI, 2004).

Para Rodrigues e Figueiredo (1996), os tópicos a serem aprendidos devem ser identificados a partir de problemas reais ou simulados e, para que os discentes os resolvam, devem recorrer aos seus conhecimentos prévios, integrando-os aos novos conhecimentos a serem adquiridos em pesquisa. Essa integração, aliada à prática, permite que haja maior retenção do conhecimento.

O PBL e outras metodologias ativas disseminadas e adotadas nas instituições de ensino nos últimos anos, surgem assim como propostas de ensino que conseguem aproximar-se do dia a dia que os gestores estão acostumados a se depararem nas empresas, a partir da discussão de problemas e tomadas de decisões simples ou mais complexas.

Apesar de autores discutirem e ressaltarem a relevância da adoção de uma metodologia de ensino mais coerente com o mundo dos negócios, ainda existem algumas dificuldades que impactam na eficiência e na sua adoção em sala de aula.

Para Rodrigues e Figueiredo (1996, p.397-398), o sucesso da adoção do PBL vincula-se a alguns pré-requisitos: os estudantes devem ter características de personalidade adequadas (independência, determinação, senso de responsabilidade, capacidade de comunicação, desinibição, capacidade de organização); o corpo docente deve ser treinado e familiarizado com o método; na organização da estrutura curricular, deve ser previsto tempo adequado para o estudo autodirigido; a instituição deve dispor da infraestrutura necessária para o auto aprendizado do aluno (material instrucional adequado e adaptado para o método, sala para reuniões de pequenos grupos, bibliotecas, laboratórios, recursos áudio-visuais).

Diante assim, do contexto apresentado, o trabalho tem como objetivo compreender a experiência de aprendizagem de estudantes de administração com base na adoção da metodologia Problem Based Learning – PBL, um projeto piloto na disciplina de Marketing 1, da Universidade Federal do Rio Grande do Norte.

2 Referencial Teórico

O PBL é um método de instrução caracterizado pelo uso de problemas da vida real para estimular o desenvolvimento do pensamento crítico e habilidades de solução de problemas e a aprendizagem de conceitos fundamentais da área de conhecimento em questão. (Ribeiro & Mizukami, 2004, p. 32)

Segundo Woods (2017), na aprendizagem baseada em problemas (PBL) os alunos usam "gatilhos" do caso-problema ou cenário para definir seus próprios objetivos de aprendizagem. Posteriormente eles fazem um estudo independente, autodirigido, antes de retornar ao grupo para discutir e aperfeiçoar os conhecimentos adquiridos. Assim, PBL não é sobre a resolução de problemas por si só, mas sim sobre usar problemas adequados para aumentar o conhecimento e a compreensão.

Este empoderamento (empowerment), isto é, a delegação de autoridade com responsabilidade sobre a aprendizagem aos alunos, prepara-os a se tornarem aprendizes por toda a vida (Barrows, 2001).

De acordo com Woods (2017), assumir responsabilidade pela própria aprendizagem em um ambiente educacional PBL significa que os alunos cumpram as seguintes tarefas:

- Exploração do problema, levantamento de hipóteses, identificação de questões de aprendizagem e elaboração das mesmas;
- Tentativa de solução do problema com o que sabem, observando a pertinência de seu conhecimento atual;
- Identificação do que não sabem e do que precisam saber para solucionar o problema;
- Priorização das questões de aprendizagem, estabelecimento de metas e objetivos de aprendizagem, alocação de recursos de modo a saberem o que, quando e quanto é esperado deles;
- Planejamento e delegação de responsabilidades para o estudo autônomo da equipe;
- Compartilhamento eficaz do novo conhecimento de forma que todos os membros aprendam os conhecimentos pesquisados pela equipe;
- Aplicação do conhecimento na solução do problema;
- Avaliação do novo conhecimento, da solução do problema e da eficácia do processo utilizado e reflexão sobre o processo.

Araújo; Araújo e Brito (2016) ainda ressaltam que, existem ainda outros aspectos que, apesar de externos, impactam na eficiência da adoção da metodologia do PBL, como essa proposta pedagógica exige muita disponibilidade de tempo do aluno para a pesquisa e leitura e, alguns alunos estudarem a noite e trabalharem a semana inteira, exercendo, simultaneamente, atividades profissionais e acadêmicas, alguns se sentem muito sobrecarregados, interferindo assim na participação e comprometimento com as atividades da disciplina.

3 Metodologia

O presente estudo investiga a percepção de discentes da disciplina de Marketing 1, no turno noturno do curso de Administração da UFRN. Compreende assim, portanto, um estudo de caso, que constitui uma abordagem metodológica de investigação especialmente adequada quando procuramos compreender, explorar ou descrever acontecimentos e contextos complexos, nos quais estão simultaneamente envolvidos diversos fatores.

O estudo constitui-se ainda uma pesquisa exploratória de natureza qualitativa, proporcionando uma visão geral acerca de determinado fato, de um tema pouco explorado. Já que o movimento de investigação qualitativa baseia-se em uma profunda preocupação do que os outros seres humanos estão fazendo ou dizendo (Schwandt, 2006).

Na busca dessa compreensão, a concepção interpretativista é coerente com a abordagem qualitativa aqui empregada. Desse modo, nessa postura epistemológica, o fenômeno a ser estudado é resultado da colocação de significados que o pesquisador impõe ao fenômeno, moldado pela maneira como ambas as partes se interagem, ambos influenciados pelas estruturas macro.

O tratamento de dados foi realizado por meio da análise de conteúdo, onde as categorias de análise surgiram a partir da sustentação teórica: participação na atividade do PBL; interação do grupo no trabalho e comprometimento com pesquisa. Para a análise dos dados, foi efetuada uma leitura dos comentários transcritos na entrevista, visando codificar e agrupar as unidades de texto – para se realizar assim a análise dos comentários dos alunos.

4 Análise dos dados

A análise dos dados foi obtida por meio das entrevistas realizadas ao final da disciplina de Marketing I, em dezembro de 2016, com os alunos matriculados, nessa unidade curricular. Foi divulgado em sala de aula na última semana de aula da disciplina sobre a realização da pesquisa e onze alunos decidiram participar espontaneamente do processo.

A primeira pergunta do roteiro de entrevista procurava entender a participação dos alunos e componentes do grupo no desenvolvimento do trabalho do PBL, a grande maioria dos respondentes que comentaram sobre as limitações na participação deles no processo, alegaram como razões para o reduzido comprometimento: a indisponibilidade de horário e problemas relacionados a falta de colaboração, conforme pode ser visualizado nos trechos, a seguir, dos discursos dos sujeitos que reforçam o resultado da pesquisa realizada por Araújo; Araújo e Brito (2016).

"Acredito que mesmo com algumas limitações relacionadas à disponibilidade de horário [...]"

"No decorrer do semestre, pude perceber que muitos colegas, assim como eu, não estavam acompanhando o ritmo de atividades [...] sem sobrecarregar os alunos, pois à noite, a turma geralmente já têm um tempo muito limitado."

"[...] apesar de deixarem para fazer os trabalhos de última hora, talvez por estarem atarefados com as outras disciplinas."

"Péssima, inclusive fui prejudicado pela não participação de certos componentes que não se comprometeram com a referida pesquisa. Dos 5 componentes apenas 2 se comprometeram e participavam de acordo com o que era pedido, os demais não procuravam saber o andamento do relatório."

Quando se reflete, assim, sobre o nível de participação dos alunos nas atividades do PBL nota-se que eles citam, de um modo geral, problemas relacionados aos aspectos socioculturais que interferem na aplicação da metodologia do PBL e consequentemente no processo de aprendizagem. Ao invés deles comentarem sobre a importância da participação deles no processo de aprendizagem com o uso dessa metodologia de ensino ativa, ao contrário disso, eles valorizaram nos seus depoimentos as justificativas que eles tinham em relação ao baixo nível de comprometimento e participação na disciplina.

Alegando fatores pessoais, tais como indisponibilidade de tempo e sobrecarga de atividades que eles possuem, além da carga de exigências da disciplina, como impactantes para o envolvimento, comprometimento e a participação deles no processo. Analisando-se os discursos dos sujeitos percebe-se uma falta de clareza e compreensão da necessidade de mudança de postura deles, para uma unidade curricular que adota uma metodologia com essas características. Nota-se que em nenhum momento eles enfatizaram nas suas falas o que eles poderiam e deveriam fazer para ampliar essa participação no processo educacional, apenas destacando justificativas pessoais para a reduzida participação, denotando deles uma postura passiva, diante de uma metodologia de aprendizagem que premia o comprometimento.

Entende-se que essa constatação nos depoimentos dos alunos, de apresentar justificativas para a reduzida participação no processo educacional, pode até ser considerada um contrassenso, uma vez que qualquer metodologia de ensino ativa adotada em sala de aula, presume a participação integral do educando, onde essas justificativas não deveriam surgir nos seus discursos. Porém, nas falas deles esse discurso foi recorrente, demonstrando a falta de compromisso e seriedade com que tratam o processo educacional e com a busca do conhecimento. Pelo que pode ser percebido no depoimento dos alunos é como se eles estivessem impregnados de costumes e hábitos culturais arraigados a metodologias tradicionais de ensino, demonstrando à passividade com que tratam o ensino, além de uma postura de acomodação, baixa autonomia e reduzido compromisso e inserção deles em um modelo dinâmico de ensino.

Como os alunos podem falar que não dispõem de tempo e estão sobrecarregados com essa e outras disciplinas, além de atividades externas, se nesse formato a participação, o envolvimento, a disponibilidade de tempo, o trabalho em equipe passam a ser fundamentais no processo educacional, onde o aprendizado se inicia no aluno e depende do envolvimento dele? Então quando os alunos entrevistados comentam que a metodologia de ensino com o PBL é muito importante, não basta relatarem a sua importância, mas deve existir uma mudança de atitude no alunado em uma ou mais disciplinas que adotam essa metodologia de ensino, diante do aprendizado centralizar-se no aluno e não no professor.

Assim, quando os alunos comentam limitações pessoais relativas à indisponibilidade de horário para pesquisa e leitura, que comprometem o engajamento e à sobrecarga de atividades para os alunos da turma da noite que já estão cansados de toda a jornada de trabalho diária e por estarem atarefados com as outras disciplinas estão, na verdade, falando em justificativas para a reduzida participação deles na sala de aula. Finalmente é como se os alunos dissessem: eu concordo que a metodologia do PBL é relevante para desenvolver pessoas nesse contexto organizacional, porém, eu e meus colegas da sala de aula possuímos alguns entraves que comprometem a nossa participação. Ressalta-se ainda que em nenhum momento os alunos apresentaram, espontaneamente, a necessidade deles mudarem sua postura para atender os princípios dessa abordagem educacional.

Outra questão evidenciada que demonstra que os alunos não tem uma noção muito clara da necessidade de mudar a postura deles e das equipes de trabalho, quando cursam uma disciplina no formato do PBL, foi quando a maior parte dos entrevistados mencionaram que existem problemas relacionados à interação do grupo e a fragmentação do desenvolvimento do trabalho. Quando essas características não fazem parte dessa abordagem, assim, percebe-se que apesar dos alunos criticarem as metodologias de ensino mais tradicionais ainda há uma relativa resistência de valores, costumes e hábitos ainda arraigados que comprometem na eficiência em relação à adoção de uma metodologia de ensino mais ativa como o PBL. Percebe-se assim que, na prática, mesmo valorizando a necessidade de aplicar uma nova metodologia de ensino, os alunos ainda adotam posturas ambíguas de desenvolvimento de atividades em sala de aula, talvez por estarem habituados a modelos mentais e estruturais pautados em metodologias tradicionais de ensino, com o uso frequente da divisão de tarefas e da falta de interação e participação, de alguns componentes e de outros não, desenvolvendo, assim as atividades da disciplina em grupo e não realizando as tarefas por meio de um trabalho em equipe.

[...] não teve a menor interação nem tampouco comprometimento de cada um discente em fazer uma determinada tarefa. Eu não chamei a atenção porque no grupo não tinham crianças, eram todos adultos e responsáveis pelos seus atos e deveres.
[...] poucos interagiam.

Não houve participação de todos os componentes na elaboração do relatório.
Era perceptível que alguns integrantes do grupo contribuíam mais do que outros, alguns não se importavam em ler o material.
Eu entendo que tem muito conteúdo, mas toda semana fica bem puxado. E acaba que temos pouco tempo para estudarmos de fato.
[...] alunos que trabalham e estudam ficam sobrecarregados, pois possuem outras disciplinas do curso também para dar conta.

Quando se perguntou aos alunos da pesquisa como eles percebiam a participação e comprometimento individual para a leitura, dos textos exigidos pela metodologia do PBL, a maior parte deles comentaram que possuam um tempo muito curto para a leitura ou possuíam um comprometimento regular para a atividade, demonstrando mais uma vez que, fatores externos tem um impacto considerável no desenvolvimento e eficiência da aplicação de uma metodologia, inclusive uma abordagem pedagógica, como o PBL, que se aproxima das exigências do contexto organizacional.

Além disso, ressalta-se que os pré-requisitos fundamentais para a aplicação da metodologia do PBL, conforme relata Woods (2017), são a participação dos alunos no desenvolvimento das atividades de pesquisa e nas de leitura, uma vez que eles se deparam com problemas que precisam ser discutidos e refletidos a partir de uma sustentação teórica.

Diante assim da falta de comprometimento dos alunos com as atividades de pesquisa e a leitura, pergunta-se assim, até que ponto a metodologia de ensino do PBL está cumprindo com o seu papel no desenvolvimento das competências de alunos que relutam por mudarem seus hábitos? Se os alunos estão ingressado na disciplina com um perfil de acomodação e passividade? Quando deveriam ter uma postura empreendedora, de autonomia e voltada para o autodesenvolvimento.

O meu tempo em decorrência de minhas atribuições profissionais e familiares é curto.
Não tinha muito tempo para ler.
Péssimo, poderia ter melhor aproveitado.
Não tive leituras muito produtivas, poderia ter aproveitado mais a disciplina.
Infelizmente pela falta de tempo para me dedicar no decorrer do semestre, acabei prejudicando meu desempenho na disciplina, embora a metodologia traga benefícios positivos [...].
[...] não tenho tempo fora de sala para ficar estudando previamente, meu conhecimento é adquirido dentro de sala, então senti muita dificuldade com relação a isso, conciliação.
[...] tentei adiantar o relatório e a apresentação, até porque sabia que não conseguiria participar bem se ficasse para fazer de última hora porque não tenho muito tempo livre, mas os outros integrantes do grupo preferiram adiar ao máximo a realização do trabalho, o que refletiu na qualidade do que foi produzido.
[...] muitos dos alunos não leram o conteúdo disponibilizado antes das aulas.

Apesar de todos esses problemas destacados pelos alunos que participaram da pesquisa, existia uma questão final que perguntava a eles como eles avaliavam a disciplina com a metodologia de PBL, o resultado demonstrou que mesmo diante de uma série de dificuldades e entraves para a adoção da proposta, a maior parte dos alunos considerou como muito positiva, de um modo geral, a experiência pedagógica, esse resultado está em conformidade com os dados obtidos na pesquisa de Ribeiro & Mizukami (2004), que destacam o PBL como uma metodologia atrativa e que se apóia no desenvolvimento de habilidades requeridas pelo mercado, embora que a questão aqui não só seja a atratividade de uma nova metodologia de ensino, mas o engajamento da equipe parece que o aluno não consegue enxergar que não é simplesmente uma mudança metodológica, além de não se inserir como responsável para mudar tudo isso, a questão maior aqui seria para que essa nova metodologia passe a existir o aluno precisa mudar a sua postura, caso ele não participe não haverá nenhuma mudança.

Achei muito mais rentável, comprometida com a realidade de mercado, com mais possibilidades de pesquisa e maleável quanto ao aprendizado, pois nem todo mundo tem o mesmo aproveitamento.

Muito boa. Realmente força o aluno a sair da sua zona de conforto e estar estudando um pouco sobre a disciplina semanalmente.
Eu gostei muito da metodologia e foi uma das matérias que mais gostei de pagar em mais de 10 períodos que estive na universidade (entre graduação e matrícula especial).

Perguntou-se ainda se o aluno tinha alguma sugestão para a melhoria da disciplina, baseado na metodologia do PBL. As respostas apresentadas demonstraram que os alunos não se colocam como agentes de mudança para que a disciplina realmente cumpra o seu papel. Embora isso tudo exista, mais existiram, ainda, outras contribuições relevantes relacionadas a pesquisa: alguns relacionados à recomendação para a adoção, não de uma metodologia pedagógica única, mas de uma pluralidade metodológica. Demonstrando assim, que alguns alunos entrevistados ainda preferem uma maior variedade de escolhas metodológicas em detrimento de uma proposta pedagógica única, talvez isso se relaciona ao perfil desse alunado, que quer mudanças sempre.

Além disso, outro aluno ainda comentou a sugestão da possibilidade de escolher o modelo de avaliação mais conveniente, optando por um modelo tradicional que premia a memorização e não a autonomia, como a prova escrita, alegando que nem todos os participantes não se comprometem como deveriam, prejudicando o desenvolvimento do trabalho e a avaliação até dos alunos mais comprometidos. Esses dados demonstram, mais uma vez, que nem sempre os alunos entendem a relevância da proposta pedagógica do PBL, como também, a importância da postura e papel do líder, na coordenação, negociação, gestão dos conflitos e das atividades da equipe para o atingimento dos objetivos do trabalho, a partir da metodologia do PBL.

Outras respostas obtidas relacionam-se, mais uma vez ao comprometimento do aluno, o tempo disponível para a leitura e o nível de exigência em relação ao desenvolvimento das atividades da disciplina, conforme discursos dos entrevistados:

Deveria ter a opção para aqueles que não aderissem a esse método, principalmente quanto às provas escritas, ficaríamos pelo menos independentes de trabalhos em grupo com pessoas sem compromisso.
Que não seja totalmente PBL, mas que seja um pouco mais diversificada.
Eu entendo que tem muito conteúdo, mas toda semana fica bem puxado. E a acaba que temos pouco tempo para estudar de fato.
Evitar mais de duas atividades por unidade, pois alunos que trabalham e estudam ficam sobrecarregados, pois possuem outras disciplinas do curso também para dar conta.

5 Conclusão

A pesquisa sobre a experiência pioneira de aprendizagem apresentada na disciplina de Marketing I, do curso de Administração da UFRN, com base na metodologia Problem Based Learning – PBL, na percepção de estudantes, compreende uma pesquisa qualitativa relevante considerando principalmente a necessidade de se descobrir achados para explorar os entraves e desafios na adoção do PBL, que impactam no desenvolvimento do processo educacional, adotando essa metodologia.

Os resultados da pesquisa demonstraram que, a avaliação da disciplina de marketing 1, adotando a proposta pedagógica do PBL, apesar de ter sido muito bem avaliada pela maior parte dos alunos pesquisados, foram identificados uma série de obstáculos que comprometem a adoção de um modelo de ensino que valoriza a participação, entraves que foram identificados ao longo do desenvolvimento da disciplina: problemas relacionados aos aspectos socioculturais do alunado interferem na aplicação da metodologia do PBL e consequentemente no processo de aprendizagem. Os alunos justificaram fatores pessoais, tais como indisponibilidade de tempo, para a leitura e pesquisa e sobrecarga de atividades, além da carga de exigências da disciplina, como impactantes para o envolvimento, comprometimento e a participação deles no processo, percebendo-se uma falta de clareza e compreensão da necessidade de mudança de postura deles em uma disciplina que adota o PBL.

Identificou-se ainda, nos alunos, costumes e hábitos culturais arraigados a metodologias tradicionais de ensino, demonstrando à passividade com que tratam o ensino, além de uma postura de acomodação, baixa autonomia e reduzido compromisso e inserção deles em um modelo dinâmico de ensino. Além disso, existem problemas relacionados à interação do grupo e a fragmentação do desenvolvimento do trabalho, onde os alunos ainda adotam posturas ambíguas de desenvolvimento de atividades em sala de aula, com o uso frequente da divisão de tarefas e da falta de interação e participação, de alguns componentes e de outros não, desenvolvendo, assim as atividades da disciplina em grupo e não realizando as tarefas por meio de um trabalho em equipe.

O estudo não se propõe a fazer generalizações, nem pretende servir como caminho único a ser trilhado por docentes e instituições. Busca assim, servir como fonte de comparação e inspiração, gerando possibilidades de pesquisas, reflexões e discussões relacionadas às dificuldades e desafios que os docentes irão se deparar com a aplicação de um novo modelo pedagógico que, apesar de ser visto como uma proposta pedagógica mais condizente com as exigências de formação mais integral das pessoas, sendo mais voltada para a realidade do dia a dia dos gestores, nesse ambiente de complexidade e inovação, para que esse modelo educacional possa realmente cumprir com o seu papel, não podem ser desconsiderados, os valores e costumes arraigados nas pessoas com modelos educacionais tradicionais apreendidas ao longo de toda a vida.

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Project 4Cs: Share Knowledge With Creativity

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Abstract

Active teaching and learning methodologies are current and innovative means for academics to be the protagonists of their training process in a context aligned with professional practices. These models has instruments capable of triggering a holistic look at the system in action by building a synergistic network of attitudes and responsibilities to achieve a common goal. The current knowledge society is inserted by an intense flow of information and sharing of skills, in structured networks and acting with heterogeneous actors. Within this environment, the development of creativity becomes a common link between the tasks for developing solutions and possibly driving the generation of innovation. In this sense, the 4Cs Integrator Project (Sharing Skills with Creativity) sought to strengthen the training of its academics in a multidisciplinary way, integrating the courses of Production Engineering, Mechanical Engineering, Design and Advertising and Propaganda. The general objective of the 4Cs was to develop a car of inertia, acting on the main characteristics of each course, from the technical criteria of the Engineering, the creativity of the Design and the communication of Advertising and Propaganda. The practices involved work in the disciplines of Project Management, Process Management, Conformation and Welding and Art Direction. The development took place through independent work that later converged in big meetings of integration, to the generation of solutions and discussions between the teams, until the final conception. The end of the project involved a competition to check vehicle performance and, especially, to strengthen integration and collaboration among academics to crown the results achieved.

Keywords: Share for Leaning; Integrator Project; Vehicle of Inertia

Project 4Cs: Compartilhar Conhecimento Com Criatividade

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Resumo

As metodologias ativas de ensino e aprendizagem são meios atuais e inovadores para que os acadêmicos possam ser os protagonistas do seu processo de formação em um contexto alinhado com as práticas profissionais. Estes modelos abrigam instrumentos capazes de desencadear um olhar holístico sobre o sistema em atuação com a construção de uma rede sinérgica de atitudes e responsabilidades para o atingimento de um objetivo comum. A atual sociedade do conhecimento está envolvida por um intenso fluxo de informações e compartilhamento de competências, em redes estruturadas e atuantes com atores heterogêneos. Dentro deste ambiente, o desenvolvimento da criatividade torna-se um elo comum entre as tarefas para elaboração de soluções e, possivelmente, impulsionar a geração da inovação. Neste sentido, o Projeto Integrador 4Cs (Compartilhar Competências Com Criatividade) buscou fortalecer a formação dos seus acadêmicos de forma multidisciplinar, integrando os cursos de Engenharia de Produção, de Engenharia Mecânica, de Design e de Publicidade e Propaganda. O objetivo geral do 4Cs foi desenvolver um carro de inércia, atuando sobre as principais características de cada de curso, a partir dos critérios técnicos das Engenharias, da criatividade do Design e da comunicação da Publicidade e Propaganda. As práticas envolveram trabalhos nas disciplinas, de Gestão de Projetos, Gestão de Processos, Conformação e Soldagem e Direção de Arte. O desenvolvimento ocorria por trabalhos independentes que depois se convergiam em grandes encontros de integração, para a geração das soluções e discussões entre as equipes, até a concepção final. O final do projeto envolveu uma competição para verificar o desempenho dos veículos e, principalmente, fortalecer a integração e colaboração entre os acadêmicos para coroar os resultados alcançados.

Keywords: Compartilhar para aprendizagem, Projeto Integrador; Carro de Inércia.

1 Introdução

Um dos grandes desafios no ensino de Engenharia é conceber e implementar modelos de ensino capazes de atender uma formação profissional alinhada aos tempos de mudanças tecnológicas. O ensino de Engenharia busca propiciar uma aprendizagem contextualizada e orientada para o uso das tecnologias contemporâneas para gerar habilidades em resolver problemas e conduzir projetos nos diversos setores produtivos. Além das competências técnicas, é indispensável que o profissional de Engenharia seja capaz de exercer valores humanos, considerados essenciais no mundo do trabalho moderno. Dentre esses valores, destacam-se uma conduta ética, com capacidade de iniciativa, criatividade e atitude empreendedora. As estratégias de aprendizagem ativa envolvem os alunos em atividades que estimulam sua capacidade de observer, analisar e desenvolver soluções. Os alunos que vivenciam esse método adquirem mais confiança em suas decisões e na aplicação do conhecimento em situações práticas, melhorando o relacionamento com os colegas, estimulando o interesse para resolver problemas. Pelo lado docente, sua função deve buscar mediar discussões, para manter alunos focados em um problema ou questão, envolvendo com tarefas de processo e estímulo ao uso das funções intelectivas de pensar, observer e raciocinar. Neste sentido, o ensino de Engenharia deve oferecer oportunidades para equilibrar a aprendizagem do conhecimento técnico tradicional com as necessidades atuais, onde o conhecimento é difuso e transdisciplinar. Por isso, este artigo tem por objetivo apresentar o Projeto Integrador 4Cs, onde aulas teóricas são complementadas por laboratórios práticos com tarefas realizadas entre grupos de alunos de diferentes cursos e disciplinas, de forma planejada e programada para atingimento de um objetivo comum. Este modelo de ensino e aprendizagem ativa demanda a capacidade criativa de geração de soluções, bem como revisitar e reconectar conhecimentos já desenvolvidos. Além do aspecto formativo educacional também se buscou desenvolver e fortalecer o relacionamento e o intraempreendedorismo dos acadêmicos.

2 Ensino e aprendizagem nos cursos de Engenharias

A organização disciplinar nas instituições de ensino instituiu-se no Século XIX (MORIN, 2002). Nos tempos atuais o avanço da ciência e a interculturalidade, trouxe o interesse por estabelecer interfaces entre saberes disciplinares, que se compartimentaliza no conhecimento humano. Por isso, os cursos superiores buscam desenvolver conhecimentos específicos que também possam tangenciar com outros conteúdos na formação dos acadêmicos. As Diretrizes Curriculares Nacionais do Brasil, dos Cursos de Graduação em Engenharia contemplam uma série de competências gerais na resolução CNE 11/2002, dentre as quais se destaca as seguintes: "V - identificar, formular e resolver problemas de engenharia"; "VIII - comunicar-se eficientemente nas formas escrita, oral e gráfica"; "IX - atuar em equipes multidisciplinares" e "XIII - assumir a postura de permanente busca de atualização profissional" (CNE, 2002). Apesar das recomendações terem sido lançadas há mais de uma década, elas ainda atendem ao atual contexto educacional, pois Mills e Treagust (2003, p. 3) afirmam que o ensino de Engenharia demanda mudanças significativas, como:

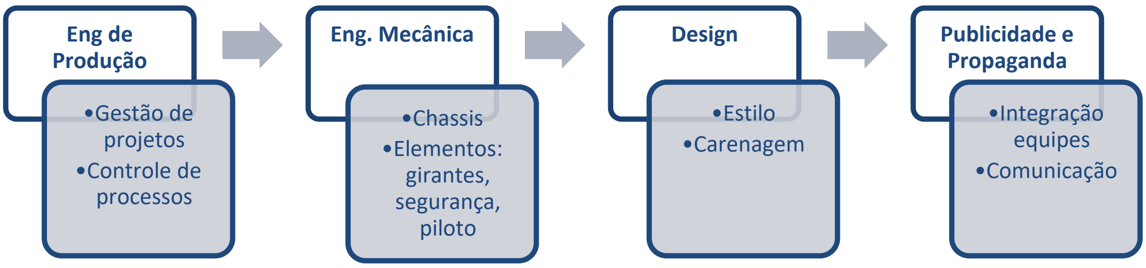
> " - O currículo de Engenharia é muito focado em Ciências e disciplinas tecnológicas, sem prover suficiente integração destes tópicos ou relacioná-los com a prática. Os programas são dirigidos para os conteúdos. - Os programas atuais não provêem experiência suficiente em projetos para os alunos. - Faltam aos alunos habilidades de comunicação e experiência de trabalho em equipes e os programas precisam incorporar mais oportunidades para os alunos desenvolve-las. - Os programas precisam desenvolver maior consciência entre os alunos de questões sociais, ambientais, econômicos e legais que são parte da realidade da prática moderna da Engenharia. - Os professores não tem experiência prática adequada, não são capazes de relacionar adequadamente teoria e prática e prover experiência de projeto. - As estratégias de ensino e aprendizagem atuais nos programas de Engenharia são desatualizadas e necessitam se tornar mais centradas nos estudantes."

Para atender estas recomendações, durante a formação dos engenheiros, é necessário propor atividades de aprendizagem para que as competências possam ser atendidas. No entanto, o caminho para atingir este propósito torna-se complexo por existirem cursos que, segundo a própria Associação Brasileira de Ensino de Engenharia (ABENGE), são "baseados em conhecimento, com enfoque no conteúdo e centrado no professor" (ABENGE, 1998). Portanto, se faz necessária, uma mudança nos métodos de ensino e aprendizagem que permita desenvolver as competências citadas. Técnicas pedagógicas devem criar espaços para aprender fazendo, aprender a aprender, trabalhar em equipes e refletir sobre o aprendizado por meio de uma comunicação oral e escrita. Desta forma, se poderá formar profissionais preparados para as atuais e novas condições de trabalho, onde a cooperação substitui a competição, seja na atuação presencial ao mesmo no trabalho digital, cada vez mais exigidas pelo mercado de trabalho. A educação precisa então estar apta para responder ao desafio de preparar esses profissionais com um devido modelo de formação e atualização profissional. Por estas características, se busca um conceito laboral em que a divisão de trabalho se torna menos acentuada, com maior ênfase na integração das funções, com trabalho cooperativo, polivalente e multifuncional. O processo de ensino-aprendizado deve contextualizar a teoria aproximando a vida acadêmica da realidade do trabalho e do cotidiano. Desta forma, a transmissão de informações para desenvolvimento do conhecimento deve ser incrementado de forma a levar à construção de competências que capacitem a tarefas intelectuais de concepção, estudo e organização necessárias ao futuro profissional (DELORS, 1998). Esta aprendizagem deve ser contextualizada, significativa e colaborativa. De acordo com a teoria da aprendizagem contextualizada, o processo ocorre somente quando o aluno articula novas informações ou conhecimentos que fazem sentido para ele em sua própria estruturação de referências, em seu mundo interior de memória, experiência e resposta (CRAWFORD, 2001). A aprendizagem significativa ocorre quando um novo conteúdo relaciona-se com conceitos já relevantes, claros e disponíveis na estrutura cognitiva do aluno e passa então a ser assimilado por este. O processo se inicia com o que é conhecido pelo aluno e o conhecimento é construído com o conteúdo considerado significativo para ele (AUSUBEL, 1978). Quanto à aprendizagem colaborativa, o aluno tem a responsabilidade pelo próprio aprendizado e pela aprendizagem dos participantes do grupo, pois o conhecimento é construído por meio da reflexão originada pela discussão entre pares (FUKS et al., 2011). A troca de informação induz o interesse e o pensamento crítico permitindo aos alunos resultados melhores do que se estivessem estudando sozinhos (CRAWFORD, 2001). Esta conexão pode ser trabalhada por meio da metodologia de Aprendizagem Baseada em Projetos (Project-Led Education - PLE) que tem como propósito básico, a promoção de uma aprendizagem ativa e centrada nos alunos. A prática do PLE está centrada no trabalho em equipes para a resolução de problemas e a articulação da teoria com a prática (POWELL; WEENK, 2003). A articulação ocorre dentro de um projeto que demande soluções a partir de um contexto real, que permita projetar o futuro cenário profissional.

2.1 Trajetória do trabalho

O processo de aprendizagem é complexo porque envolve interações diferentes, muitas vezes, sobrepondo teorias ou pensamentos entre educandos e o educador. Tendo em vista a aplicação de uma pedagogia moderna e alinhada às necessidades contemporaneas, o projeto seguiu os princípios da PLE. A estrutura de trabalho foi guiada por aprendizagem ativa e colaborativa entre disciplinas e cursos distintos, conforme ilustra o diagrama abaixo;

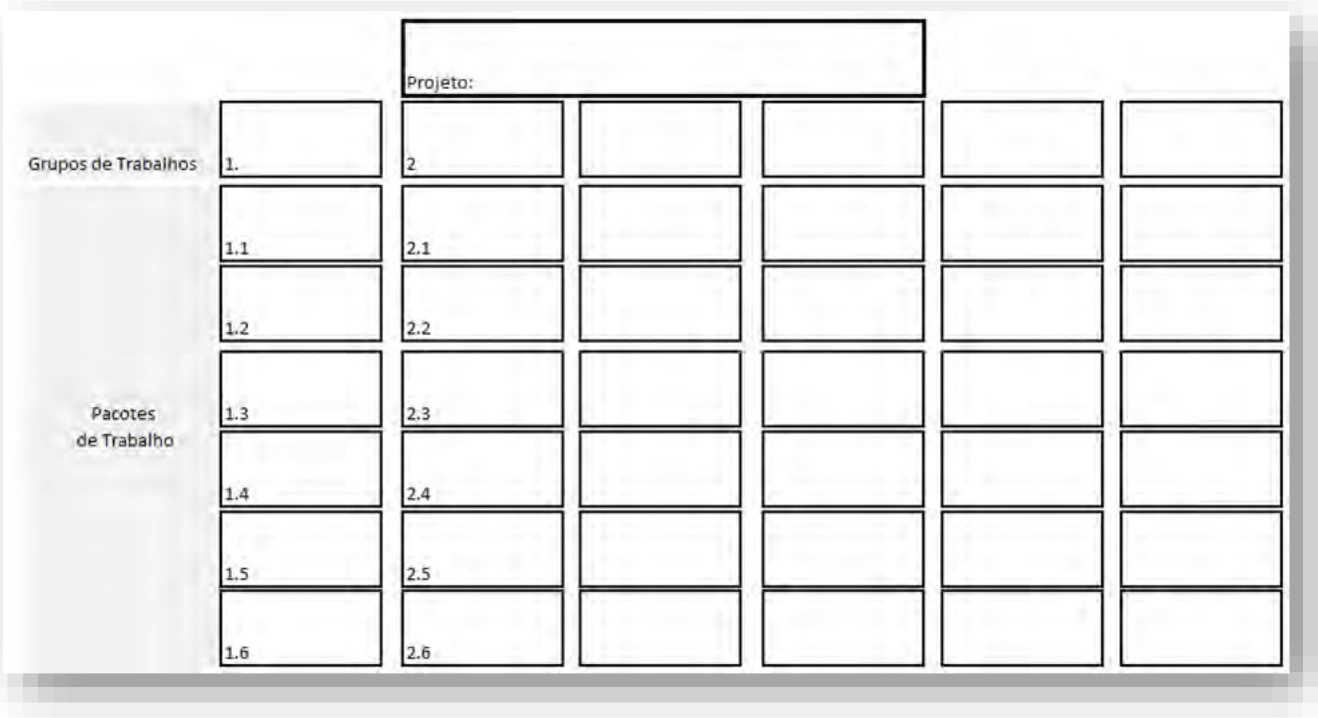
Diagrama 1: Estrutura temática de trabalho dos cursos



Em cada disciplina de cada curso eram propostos objetivos pontuais que representavam os subconjuntos do produto, por exemplo, o chassis, os elementos girantes, o conjunto do piloto e a carenagem. O grupo do curso de Design, definiu quatro marcas de montadoras, e criou as carenagens remetendo o estilo marcante de cada fabricante. Os alunos de Publicidade tiveram o desafio de desenvolver a forma de integração dos trabalhos e a comunicação do evento. As Engenharias tinham o propósito de desenvolver e montar os veículos, respeitando critérios de segurança em períodos determinados. Em todos os casos, o cumprimento científico proposto na ementa da matéria, era executado em conjunto com as práticas de trabalho. As ações ocorriam dentro de prazos pré-estabeleciodos porque a cada três semanas os grupos se reuniam para averiguar os resultados de cada atividade parcial. Desta forma, as equipes poderiam verificar a integração das partes para compor o veículo. Da orientação geral dos trabalhos até o regulamento da competição, tudo estava redigido em um procedimento do projeto, para finalizer dentro do semester letivo. Para demonstrar as partes da execução dos trabalhos, as figuras de 1 a 4 ilustram as atividades.

A estrutura organizacional das equipes e suas atividades de trabalho:

Figura 1: Organização das atividades



As Fichas de controle dos processos estão apresentadas na figura 2:

Figura 2: Fichas de controle dos processos

DIAGRAMA DE FLUXO DE PROCESSO										
Cliente:						Prosuto:			Elaborado:	Data Emissão:
						Desenho n.:	Revisão:		Aprovado:	Data Revisão:
Etapa Processo	Operação	Mover	Armazenar	Inspecionar	Monitorar	DESCRIÇÃO DA OPERAÇÃO	CARACTERÍSTICA ESP.		PARÂMETROS PRINCIPAIS	
							CLIENTE	EMPRESA	PROCESSO	PRODUTO

A Estrutura padrão do chassis criada no laboratório de desenvolvimento do produto:

Figura 3: Chassis

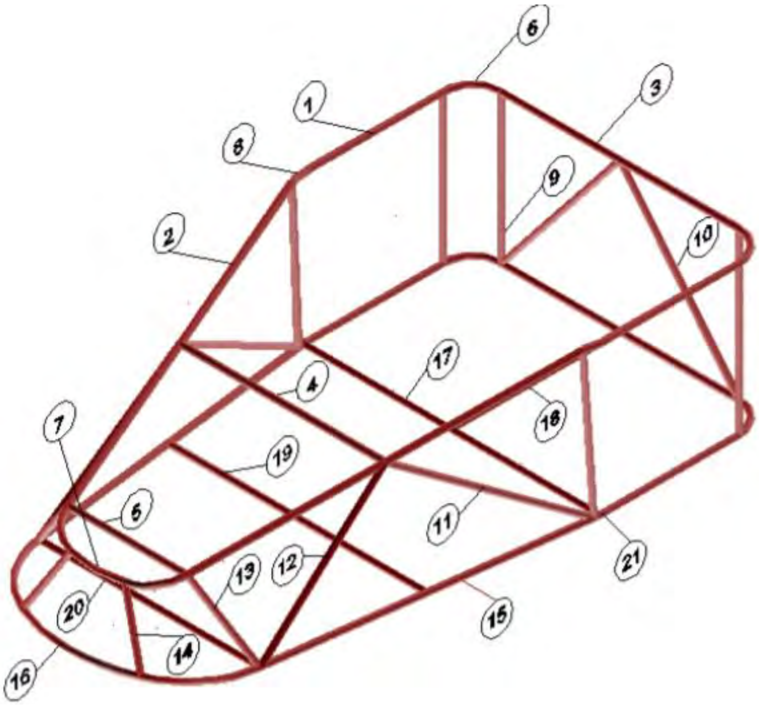


Foto de todas as equipes envolvidas, colegas e professores envolvidos em todo o projeto, na figura 4:

Figura 4: Foto do evento

Figura 5: Fotos de veículos de inércia

3 Resultados

Como resultados alcançados, na óptica educacional, observou-se que os acadêmicos realizaram as entregas parciais dos trabalhos de acordo com os objetivos estabelecidos pelo cronograma geral de trabalho, portanto, em sintonia com os conceitos disciplinares trabalhados em gestão de projetos. Na ótica de temas profissionalizantes, esta dimensão foi atingida no contexto da segurança e do controle dos processos nos laboratórios. Sobre a dimensão interdisciplinar, os alunos desenvolveram seu senso criativo na geração de soluções simples e, muitas vezes, com a introdução de materiais reciclados. Os alunos também puderam relacionar conceitos básicos da física em relação a minimização do atrito e do equilíbrio dinâmico. Em relação aos aspectos de aprendizagem ativa e colaborativa, foram praticados discussões nas equipes, com atuação sobre a gestão e divisão dos trabalhos, com aplicação de mapas mentais para aprofundamentos de ideias e soluções, e realizado interações externas com profissionais experientes da área. Assim, os alunos puderam melhorar seus relacionamentos, seu potencial criativo e amadurecer sua atuação cooperative, dentro de um modelo acadêmico que poderá auxiliar na sua futura atuação profissional.

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Cost optimization through project-based interdisciplinarity

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Abstract

This paper consists of constructing a mathematical model capable of reproducing the best composition of raw materials in order to optimize the costs of the process. The research has an exclusively didactic-pedagogical aim in order to define, through the disciplines involved, relevant elements in the process of formation of egress in Production Engineering. The correlation of disciplines such as Linear Programming, Economic Engineering allow the student to have an understanding of the industrial production process, being structuring in the formation of the egress of the Production Engineering Course. The project is aligned with the objectives of the course and the intended profile of the egress in terms of skills: qualitative and quantitative analysis, communication, opportunity, learning always, group work, context, design and diagnosis. The adoption of the project-centered learning model consists of a methodology that emphasizes teamwork, the resolution of interdisciplinary problems and the articulation of theory and practice, culminating in the presentation of a real situation related to the future professional context. Emphasis is on student learning and its active role in this process, in order to develop not only technical skills, but also transversal skills or soft skills. For the validation of the mathematical model defined through Linear Programming, the SOLVER tool of Microsoft Excel was used, in which it was possible to provide reports with economic data for the process attendance at the lowest possible cost. The results demonstrate the importance of the Linear Programming tool in an economic analysis of a manufacturing process.

Keywords: Manufacture of paint; Linear Programming; Cost Reduction; Solver.

Otimização de custo por meio da interdisciplinaridade baseada em projetos

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Resumo

Este trabalho consiste em construir um modelo matemático capaz de reproduzir a melhor composição de matérias primas a fim de otimizar os custos do processo. A pesquisa tem objetivo exclusivamente didático-pedagógico no intuito de definir por meio das disciplinas envolvidas elementos relevantes no processo de formação do egresso em Engenharia de Produção. A correlação de disciplinas como Programação Linear, Engenharia Econômica permitem fazer com que o aluno tenha um entendimento do processo produtivo industrial, sendo estruturante na formação do egresso do Curso de Engenharia de Produção. O projeto alinha-se aos objetivos do curso e ao perfil pretendido do egresso quanto às competências: análises qualitativa e quantitativa, comunicação, oportunidade, aprender sempre, trabalho em grupo, contexto, projeto e diagnose. A adoção do modelo de aprendizagem centrado em projeto consiste numa metodologia que enfatiza o trabalho em equipe, a resolução de problemas interdisciplinares e a articulação teoria e prática, que culmina com a apresentação de uma situação real, relacionada com o futuro contexto profissional. A ênfase é a aprendizagem do aluno e o seu papel ativo neste processo, a fim do desenvolvimento não só de competências técnicas, mas também de competências transversais ou *soft skills*. Para validação do modelo matemático definido por meio de Programação Linear foi utilizado a ferramenta SOLVER do *Microsoft Excel*, na qual foi possível disponibilizar relatórios com dados econômicos para o atendimento do processo ao menor custo possível. Os resultados demonstram a importância da ferramenta de Programação Linear em uma análise econômica de um processo de fabricação.

Palavras-chave: Fabricação de tinta; Programação Linear; Redução de Custos; Solver.

1 Introdução

O Brasil é um dos cinco maiores mercados mundiais para tintas, fabricando-se tintas destinadas às mais variadas aplicações, com tecnologia de ponta e grau de competência técnica comparável à dos mais avançados centros mundiais de produção (ABRAFATI, 2013).

A pesquisa operacional e, em particular, a programação matemática trata de problemas de decisão e faz uso de modelos matemáticos que procuram representar (em certo sentido, imitar) o problema real. Variáveis são definidas e relações matemáticas entre essas variáveis são estabelecidas de forma a descrever o comportamento do sistema. O modelo matemático é resolvido e o passo seguinte consta na validação do modelo, isto é, verificar se as soluções obtidas pela resolução do modelo matemático para diversas situações alternativas são compatíveis com a realidade. A solução do modelo apoia o processo de tomada de decisões, mas em geral diversos outros fatores pouco tangíveis, não quantificáveis, também devem ser levados em consideração para a decisão final. Convém salientar que modelos não substituem tomadores de decisão.

O interdisciplinar tem um importante peso na formação do aluno, ele consegue colocar tudo, ou pelo menos grande parte, do que foi passado em sala para ser mostrado na prática, deixando assim muito mais simples de se compreender a matéria e as suas aplicações práticas, além de estimular os alunos a trabalharem em equipe, o que é algo muito importante hoje em dia para o mercado de trabalho, pode-se observar o interdisciplinar como um grande teste para o final de semestre, uma espécie de provão para testar os conhecimentos práticos e lógicos dos alunos.

O projeto consiste em construir um modelo matemático que permitirá reduzir os custos de fabricação utilizando a ferramenta SOLVER (*Microsoft Excel*), a fim de identificar a melhor composição de matérias-primas para atingir o menor custo de fabricação em um processo de fabricação de tintas. Propõe-se trabalhar com dois modelos de tinta, secante e ultra seca, tendo elas a composição de óleo de soja e silicato de potássio. Para o cumprimento do objetivo de custo, definiu-se um projeto interdisciplinar por meio da aplicação da técnica de programação linear.

O projeto interdisciplinar tem um importante peso na formação de um aluno, ele consegue colocar tudo, ou pelo menos grande parte, do que foi passado em sala para ser mostrado na prática, deixando assim muito mais simples de se compreender a matéria e as suas aplicações práticas, além de estimular os alunos a trabalharem em equipe. A expectativa com esse trabalho é conseguir, por meio da utilização de programação linear, otimizar um processo de fabricação de tinta, atendendo as mínimas restrições, ou seja, não perder a qualidade do produto final.

2 Fundamentação Teórica

2.1 Processo de Fabricação de Tinta

A principal composição para obtenção da tinta é por: aditivos, solventes, pigmentos e veículo fixo.

> A tinta é uma mistura de pigmentos, solventes, aditivos e adesivos ou colas. Os pigmentos são as substâncias que conferem cor, enquanto os líquidos e adesivos servem para dar a fluidez, ou seja, a viscosidade necessária para transportar e fixar os pigmentos na superfície. Os pigmentos e adesivos podem ser de origem mineral, animal, vegetal ou sintética, enquanto os líquidos podem ser água, óleos ou solventes (CARVALHO, 2009).

Os aditivos têm funções específicas como conferir importantes propriedades às tintas e aos revestimentos respectivos, tais como: aumento da proteção anticorrosiva, bloqueadores dos raios UV, catalisadores de reações, dispersantes e umectantes de pigmentos e cargas, melhoria de nivelamento, preservantes e antiespumantes. Existe uma variedade enorme de aditivos usados na indústria de tintas e vernizes: secantes, anti sedimentares, niveladores, anti nata, antiespumante, etc. Já os solventes são compostos (orgânicos ou água) responsáveis pelo aspecto líquido da tinta com uma determinada viscosidade. Após a aplicação da tinta, o solvente evapora deixando uma camada de filme seco sobre o substrato. São adicionados à tinta para torná-la mais fluida. Algumas tintas são classificadas de acordo com o solvente. As tintas de látex, por exemplo, são diluídas com água e são chamadas tintas à base de água. Tintas insolúveis em água requerem solventes orgânicos, como subprodutos de petróleo. Essas tintas são denominadas tintas à base de solvente.

> Os solventes são compostos (orgânicos ou água) responsáveis pelo aspecto líquido da tinta com uma determinada viscosidade. Após a aplicação da tinta, resta uma camada de filme seco sobre o substrato, formada por alguns processos, tais como a evaporação do filme. O principal objetivo do solvente é ajustar as propriedades de cura e a viscosidade da tinta. Também controla a reologia e as propriedades da aplicação, e afeta a estabilidade da tinta enquanto esta se encontra no estado líquido. A sua função principal é funcionar como transportador dos componentes não voláteis, podendo ser um componente opcional numa tinta. A água é o principal solvente das tintas de base aquosa. As tintas de base solvente podem ter várias combinações de solventes como diluente, que podem incluir hidrocarbonetos, álcoois, cetonas e éter de petróleo (SOARES, 2012).

A pigmentação são substâncias insolúveis no meio em que são utilizados (orgânico ou aquoso) e têm como finalidades principais conferir cor ou cobertura às tintas. Os corantes são substâncias geralmente solúveis em água e são utilizados para conferir cor a um determinado produto ou superfície.

> Os pigmentos são constituídos de pequenas partículas sólidas de granulometria fina, os quais após o tempo de secagem proporcionam a formação da camada uniforme que reveste o substrato. Este material além de conferir cor, pode aumentar o brilho, opacidade, durabilidade e resistência à corrosão. Por isso, os pigmentos são utilizados pelo homem com finalidades

decorativas e artísticas desde muito tempo, podendo ser retirados de vegetais ou minerais (FAZENDA, 1995 apud FÜCHTER, 2007).

O veículo fixo serve para unir as partículas de pigmentos. Os veículos ou aglutinadores incluem óleos, vernizes, látex e resinas naturais e sintéticas. Por exemplo, um veículo de látex é obtido através da suspensão de partículas de resina sintética em água. Essa suspensão é chamada de emulsão. Tintas que utilizam esses veículos são denominadas tintas látex, ou emulsão. Quando um veículo entra em contato com o ar, seca e endurece. Essa ação transforma a tinta em uma película rígida que retém o pigmento sobre a superfície.

2.2 Programação Linear

Segundo Duckworth (1972), Pesquisa Operacional é uma técnica adotada em situações onde existem vários produtos a serem fabricados, com o auxílio de máquinas e a necessidade de programas com o intuito de decidir acerca da máquina a ser utilizada para a fabricação de cada produto, levando em conta a produção máxima, o custo mínimo ou qualquer que seja o critério de eficácia. A PL surgiu como um dos mais importantes ramos da programação matemática devido a sua vasta aplicação prática. Com o avanço tecnológico ocorrido a partir da segunda metade do século XX, os algoritmos se tornaram ainda mais eficientes e favoráveis para a resolução de uma larga variedade de problemas envolvendo questões de decisão em vários domínios, entre os quais podem ser citados o planejamento da distribuição e produção de produtos, no planeamento de curto prazo em aproveitamento hidroelétricos e nas decisões ligadas às políticas microeconômicas e macroeconômicas de governo dos países (SOUSA, 2014).

Em Pesquisa Operacional, a modelagem consiste em traduzir a realidade empírica para sentenças lógicas e dados objetivos. Através dessa tradução é possível estabelecer um modelo matemático. Esse é primeiro passo para a resolução do problema de Pesquisa Operacional, e é denominado formulação. Nele é decidido, por julgamento humano, os aspectos do sistema real que deverão ser incorporados ao modelo e os que poderão ser ignorados, as suposições que poderão ser consideradas e as que podem ser descartadas. O processo, porém, está sujeito a erros e falhas de comunicação. Para o estabelecimento do modelo de um problema, não existem técnicas precisas, capazes de permitir o estabelecimento do modelo de um problema. (TAHA, 2008).

2.3 Educação no Ensino da Engenharia

Para Morán (2015) é muito importante que as metodologias de ensino aprendizagem sejam acompanhadas por objetivos pretendidos pela instituição e aprendizagem aos alunos. Se a instituição quer que seus alunos sejam proativos, é necessário adotar metodologias em que os mesmos se envolvam em atividades, com cada vez mais interesse, em que tenham que tomar decisões e avaliar os resultados, com apoio de materiais relevantes para autoconhecimento.

Já Bostrom, Gupta e Hill (2008) descreve que um conjunto estruturado de atividades pedagógicas serve de guia, fonte de feedback e promove a aprendizagem colaborativa. Segundo estes autores, uma revisão da literatura educacional indica que as estratégias de aprendizagem das organizações acadêmicas estão se deslocando para uma aprendizagem mais ativa e voltada ao aluno como protagonista é denominada aprendizagem cooperativa ou colaborativa.

Segundo Toledo *et al.*, (2013), isso não significa que as instituições precisam ser as melhores em todas as dimensões da qualidade, porém é preciso determinar prioridades, já que dificilmente existe uma organização tantos recursos capazes de executar a excelência em todas as dimensões. O mais importante é que cada instituição pesquise quais são as dimensões de qualidade mais valorizadas e adotar estratégias em seus sistemas de operações de serviços para geração desse valor.

2.4 Inovação – Iniciativa CDIO

Analisando as necessidades da Educação em Engenharia segundo as exigências e conselhos da indústria e de outras partes interessadas em relação aos conhecimentos, habilidades e habilidades desejados dos futuros engenheiros sintetizando em listas de atributos, as instituições de ensino foram conduzidas por uma necessidade mais básica, ou seja, a razão pela qual a sociedade precisa de engenheiros, em primeiro lugar (CRAWLEY, BRODUER e SODERHOLM, 2008). Os autores descrevem o ponto de partida da Iniciativa CDIO (*Conceived-Design-Implement-Operate*) na atualização da necessidade subjacente de educação de engenharia acreditando que todo engenheiro graduado deve ser capaz de: Conceber-Projetar-Implementar-Operar produtos, processos e sistemas complexos de engenharia de valor agregado em ambientes modernos baseados em equipe na qual terão a responsabilidade de executar uma sequência de tarefas, a fim de projetar e implementar um produto, processo ou sistema dentro de uma organização.

Kon e Sale (2010), apresentam a grande renovação curricular além da revisão crítica do conhecimento técnico e habilidades das estruturas dos cursos e seus módulos diante da infusão sistemática de uma variedade de habilidades de CDIO. Segundo os autores, o destaque da Iniciativa está no pensamento crítico e criativo de sistemas e no gerenciamento de aprendizagem (habilidades e atributos pessoais e profissionais), trabalho em equipe e comunicação (habilidades interpessoais) e conceber, projetar, implementar e operar sistemas em um contexto de engenharia do mundo real.

2.5 Projetos Interdisciplinares

Para Bonatto *et al.*, (2012) a interdisciplinaridade é um elo entre o entendimento das disciplinas nas suas diversas áreas. Sua importância está relacionada ao fato da possibilidade de abranger temáticas e conteúdo, permitindo dessa forma recursos inovadores e dinâmicos, em que as aprendizagens são ampliadas.

A interdisciplinaridade corresponde a uma nova consciência da realidade, a um novo modo de pensar, que resulta num ato de troca, reciprocidade e integração entre áreas diferentes de conhecimento, visando tanto a produção de novos conhecimentos, quanto a resolução de problemas, de modo global e abrangente. (FAVARÃO e ARAÚJO, 2004).

Estudos interdisciplinares irão preparar os alunos para enfrentar o comportamento complexo que enfrentarão na sua vida profissional futura. A maioria das empresas modernas está procurando contratar graduados com habilidades interdisciplinares, por isso é importante para as universidades e instituições de ensino incentivar programas interdisciplinares (VANSTONE e OORSCHOT, 2013).

Há várias razões por trás da mudança da educação tradicional para a liderada pelo projeto no ensino superior. Helle *et al.*, (2006) distinguem três categorias que são relevantes. Primeiro, há motivos profissionais: a aprendizagem deve ser mais baseada no trabalho e voltada para a prática profissional. Fomentar o pensamento crítico pode ser uma segunda razão para embarcar em uma mudança para a aprendizagem baseada em projetos. Motivos pedagógicos que compreendem uma melhor compreensão dos temas também justificam esta mudança na abordagem de aprendizagem.

3 Materiais e Método

O presente Projeto Interdisciplinar aplica-se ao Curso de Engenharia de Produção, especificamente às turmas do 6º SEM letivo, do presente ano de 2017. Trata-se de trabalho em equipes, a serem formados por seis alunos de uma mesma turma. A formação das equipes deverá ser feita de forma "livre escolha" entre os alunos. O projeto consiste em construir um modelo matemático que permitirá otimizar os custos de fabricação utilizando-se, necessariamente, da ferramenta SOLVER, a fim de identificar a melhor composição de matérias-primas para atingimento do menor custo de fabricação.

Para o desenvolvimento do projeto, algumas premissas foram adotadas:

- Produção de Tinta:
    - 2 modelos produzidos: Secante e Ultra Seca
    - Ambas são produzidas à partir de óleo de soja e base de silicato de potássio
- As matérias primas permitem realizar duas soluções preliminares:
    - Solução Tipo I: 55% de silicato e 45% de óleo
    - Solução Tipo II: 20% de silicato e 80% de óleo
- Preço:
    - Óleo de soja: R$ 2,00/L

- Silicato de potássio: R$ 1,50/L
- Solução Tipo I: R$ 0,60/L
- Solução Tipo II: R$ 0,80/L

▪ Composição da Tinta:

- Secante: mínimo 25% de silicato e 50% de óleo
- Ultra Seca: mínimo 20% de silicato e máximo 50% de óleo

Diante das premissas, as equipes multidisciplinares deveriam responder a seguinte questão de pesquisa: Qual é a combinação necessária para a produção de 150 litros de Tinta Secante e 350 litros de Tinta Ultra Seca?

Para realização do projeto, foram identificadas as disciplinas participantes do 6º semestre do curso de Engenharia de Produção, conforme Quadro 1.

Quadro 21. Matriz de Contribuição.

Disciplinas	**Contribuição**
Engenharia Econômica	Minimização dos custos em processos de fabricação
Pesquisa Operacional	Modelagem Matemática. Aplicação de ferramenta Solver
Processos de Fabricação	Conceitos básicos para fabricação de produtos por meio de seleção de matérias primas

A disciplina de Engenharia Econômica apresenta-se como o elo entre as demais, sendo a disciplina integradora. Os alunos da disciplina precisam compreender que para um problema de custos por exemplo, não podemos ficar na tentativa e erro, e sim apresentar uma abordagem matemática para resolução do problema.

Já a disciplina de Pesquisa Operacional vem como suporte da interdisciplinaridade. Pois a resposta ao problema proposto, obriga os alunos a entenderem e compreenderem os conceitos de programação linear para otimização de processos, deste a coleta de dados a analises das restrições impostas pelo processo estudado.

Por fim, a disciplina de Processos de Fabricação traz o exemplo a ser estudado, que no caso, refere-se a um processo de fabricação de tintas, onde obrigou-se os alunos a estudarem o tema e aprenderem como funciona tal processo, visto que era algo de novo não visto em sala de aula.

Para cumprimento dos objetivos, definiu-se um cronograma com as principais atividades entre alunos e professores (Figura 1).

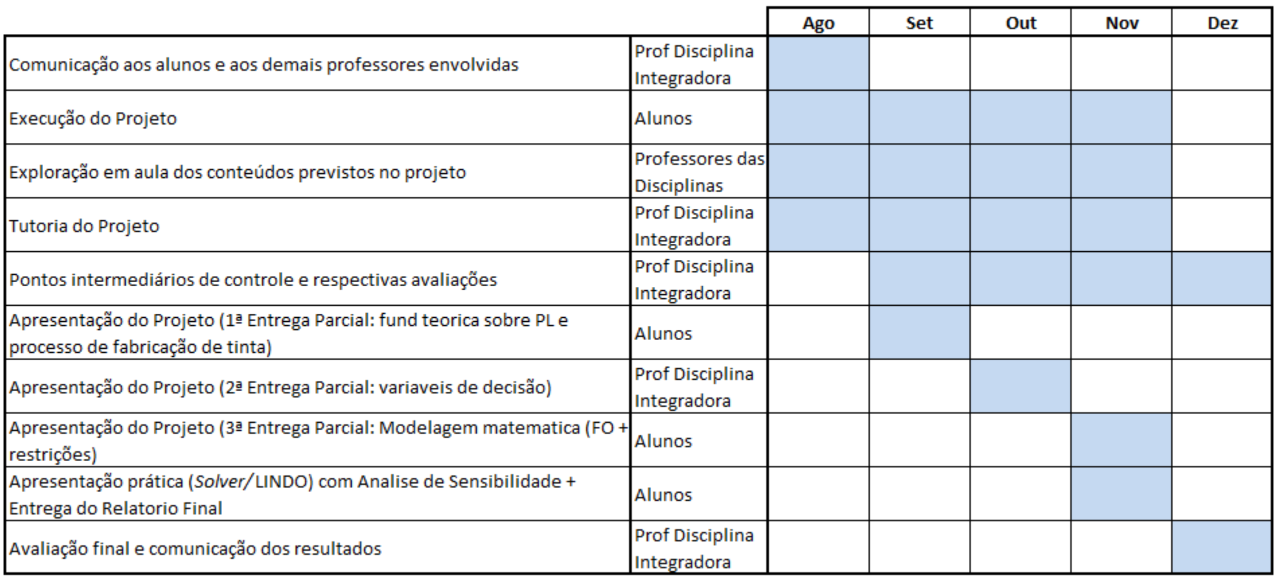

Figura 40. Cronograma de Atividades.

A pesquisa partiu de uma apresentação do projeto à alunos e professores para que todos tivessem o mesmo nível de entendimento e compreensão em relação aos objetivos envolvidos. A execução do projeto decorre-se nos meses seguintes ao longo do semestre letivo, sendo acompanhado pelo professor da disciplina integradora.

Ao final de cada mês, era apresentado pelos alunos e avaliado pelo corpo docente as entregas parciais. O objetivo com estes *gates reviews* era verificar o que fora feito até o momento e direcioná-los nas próximas atividades, permitindo assim uma avaliação continuada ao longo de toda a fase do projeto.

Ao final, tinha-se como última entrega a modelagem computacional juntamente com o relatório final, onde os alunos expuseram suas dificuldades, aprendizados e limitações ao longo do desenvolvimento do projeto.

4 Apresentação dos Resultados

Como primeira entrega, os alunos realizaram um relatório abordando uma revisão teórica sobre Programação Linear e Processo de Fabricação de Tintas. Os relatórios foram avaliados pelo professor da disciplina integradora, sob a ótica da realização da pesquisa acadêmica. Os alunos utilizaram-se de pesquisas realizadas no Google Acadêmico e Scielo por meio de palavras chaves previamente definidas. Nesta fase, utilizou-se para o levantamento teórico proposto, a técnica da bibliometria a fim de identificar as publicações com maior impacto, dada à frequência de citações da publicação, sobre os temas Programação Linear, Otimização de Processo e Solver. Com o objetivo de observar a aplicação e difusão de métodos quantitativos voltados a analisar o comportamento de comunidades, autores e publicações em outras áreas de conhecimento, a bibliometria tem um papel relevante na análise da produção científica de um país, uma vez que seus indicadores podem retratar o comportamento e desenvolvimento de uma área do conhecimento (ARAÚJO; ALVARENGA, 2011).

Para a segunda entrega, os alunos apresentaram as variáveis de decisão necessárias para realização do projeto, sendo identificadas oito variáveis ao total:

X_1: solução tipo 1 para secante
X_2: solução tipo 2 para secante
X_3: óleo de soja para secante
X_4: silicato de potássio para secante
X_5: solução tipo 1 para ultra seca
X_6: solução tipo 2 para ultra seca
X_7: óleo de soja para ultra seca
X_8: silicato de potássio para ultra seca

Com o andamento do projeto, os alunos definiram por meio de pesquisas todas as restrições do projeto assim como a função objetivo sendo uma função da matéria-prima na confecção das tintas, conforme equação 1:

$$\text{Min } 0{,}60(X_1+X_5) + 0{,}80(X_2 + X_6) + 2(X_3 + X_7) + 1{,}5(X_4 + X_8) \qquad (1)$$

As restrições de projeto foram definidas como restrições de produção, segundo as equações 2 e 3:

$$X_1+X_2+X_3+X_4 = 150 \qquad (2)$$
$$X_5+X_6+X_7+X_8 = 350 \qquad (3)$$

Outras restrições definidas foram por tipo de componente, como seguem as equações 4, 5, 6 e 7:

$$0{,}55X_1 + 0{,}2X_2 + X_4 >= 0{,}25(X_1 + X_2 + X_3 + X_4) \rightarrow \text{silicato secante} \qquad (4)$$
$$0{,}45X_1 + 0{,}8X_2 + X_3 >= 0{,}5(X_1 + X_2 + X_3 + X_4) \rightarrow \text{óleo secante} \qquad (5)$$
$$0{,}55X_5 + 0{,}2X_6 + X_8 >= 0{,}20(X_5 + X_6 + X_7 + X_8) \rightarrow \text{silicato ultra seca} \qquad (6)$$
$$0{,}45X_5 + 0{,}8X_6 + X_7 <= 0{,}50(X_5 + X_6 + X_7 + X_8) \rightarrow \text{óleo ultra seca} \qquad (7)$$

Por fim, definiu-se as restrições de não-negatividade, apresentada na equação 8:

$$X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8 >= 0 \qquad (8)$$

Com a função objetivo definida pela equação 1 e as restrições conhecidas matematicamente pelas equações 2 a 8, o modelo pode ser desenhado na ferramenta SOLVER para a obtenção do resultado final com resposta de um custo total de R$ 304,29, conforme Figura 2 e Figura 3.

	TINTA SECANTE				TINTA ULTRA SECA			
	Solução I	Solução II	Óleo	Silicato	Solução I	Solução II	Óleo	Silicato
	X1	X2	X3	X4	X5	X6	X7	X8
Valor/L (R$)	0,6	0,8	2	1,5	0,6	0,8	2	1,5
Qtd Ideal (L)	128,571428	21,4285718	0	0	350	0	0	0
Função Objetiva	94,28571436				210			
Zmin Total	304,2857144							

Figura 41. Composição das variáveis.

	Restrições Técnicas	COEFICIENTES DE VARIÁVEIS								Quantidade (L)	Exigência	Quantidade Exigida
	Nº	X1	X2	X3	X4	X5	X6	X7	X8			
Óleo	1	0,45	0,8	1	0	0	0	0	0	75,00000013	>=	75
Silicato	2	0,55	0,2	0	1	0	0	0	0	74,99999987	>=	37,5
Todo	3	1	1	1	1	0	0	0	0	150	=	150
Óleo	4	0	0	0	0	0,45	0,8	1	0	157,5	<=	175
Silicato	5	0	0	0	0	0,55	0,2	0	1	192,5	>=	70
Todo	6	0	0	0	0	1	1	1	1	350	=	350

Figura 42. Restrições de projeto.

5 Conclusão

A pesquisa por meio do projeto interdisciplinar permitiu identificar que não há obrigatoriedade de termos todas as variáveis presentes na melhor resposta, visto que algumas delas apresentaram-se nulas dentro da quantidade ideal, conforme visto na Figura 2. O modelo também permitiu realizar analise de sensibilidade quanto a variação da demanda inicial do projeto, podendo assim dentro do conceito de programação linear trabalhar com vários mínimos locais até a busca do mínimo global.

É importante que se trabalhe como futuro Engenheiro de Produção o desenvolvimento de modelos matemáticos para representações do mundo real. Isto permite que o aluno tenha uma visão holística sobre o ambiente que o cerca.

O projeto alinha-se aos objetivos do curso e ao perfil pretendido do egresso em especial quanto às competências: análise qualitativa/quantitativa, trabalho em equipe, contexto, projeto e diagnose, resolução de problemas interdisciplinares e a articulação teoria e prática. Pode-se observar o interdisciplinar como um grande teste para o final de semestre, uma espécie de provão para teste dos conhecimentos práticos e lógicos dos alunos.

As nossas decisões são muito importantes, afinal elas que dizem quem nós somos ou vamos nos tornar, dessa maneira a programação linear pode auxiliar muito nessas tomadas de decisões, ela consegue mostrar o melhor caminho a se tomar, ou a melhor oportunidade a se aproveitar. De maneira simples, é uma ferramenta de auxílio na tomada de decisão.

O trabalho permitiu o aluno ter um ponto focal de pesquisa. A ênfase é a aprendizagem do aluno e o seu papel ativo neste processo, a fim do desenvolvimento não só de competências técnicas, mas também de competências transversais ou *soft skills*.

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The application of Project Based Learning through Integrative Projects as a hands-on methodology for the development of competencies

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Abstract

The use of active learning methodologies is being discussed more and more by higher education institutions in Brazil and in the world. Technological advances and the differentiated profile of new students are some of the reasons why many institutions are rethinking their teaching and learning processes. In this context, the use of active methodologies in engineering courses has been the subject of constant discussions and questioning by teachers and institutions. The objective of this work is to report the experience in the application of PBL - Project Based Learning in the engineering courses of a University Center in Brazil. The main motivation for choosing the PBL was the application of interdisciplinarity and also the need to use a hands-on methodology for skills development. The methodology presented in this paper is a case study that aims to present an overview of the application of the PBL in projects integrating engineering courses and how this methodology enabled the development of competencies. The method used to collect the data to demonstrate the students' perspective was a two-part survey: at the beginning and at the end of the development of the integrating projects. The information obtained shows a greater engagement of students and improvement in the teaching and learning process. The application of new teaching and learning methodologies should be widely discussed with the teachers and coordinators of the courses, in order to first identify which competences they intend to develop and identify the methodology that best applies. The alignment and qualification of all teaching staff for the use of new methodologies in the classroom is of paramount importance and the educational institution must provide actions that contribute to the implementation of new methodologies and resources in the teaching and learning process.

Keywords: project-based learning; integrating projects; engineering teaching.

A aplicação do Project Based Learning através de Projetos Integradores como metodologia hands-on para o desenvolvimento de competências

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Resumo

O uso de metodologias ativas de aprendizado está sendo discutido cada vez mais por instituições de ensino superior no Brasil e no mundo. Os avanços tecnológicos e o perfil diferenciado dos novos alunos são algumas das razões pelas quais muitas instituições estão repensando seus processos de ensino e de aprendizagem. Neste contexto, o uso de metodologias ativas em cursos de engenharia, tem sido objeto de constantes discussões e questionamentos por parte dos docentes e instituições. O objetivo deste trabalho é relatar a experiência na aplicação do PBL - *Project Based Learning* nos cursos de engenharia de um Centro Universitário no Brasil. A principal motivação para a escolha do PBL foi a aplicação da interdisciplinaridade e também a necessidade de usar uma metodologia *hands-on* para o desenvolvimento de competências. A metodologia apresentada neste artigo é um estudo de caso que visa apresentar uma visão geral da aplicação do PBL em projetos integradores dos cursos de engenharia e como essa metodologia possibilitou o desenvolvimento de competências. O método utilizado para a coleta dos dados destinado a demonstrar a perspectiva dos alunos foi um levantamento elaborado em duas partes: no início e ao final do desenvolvimento dos projetos integradores. As informações obtidas mostram um maior engajamento dos alunos e melhora no processo de ensino e de aprendizagem. A aplicação de novas metodologias de ensino e aprendizagem deve ser amplamente discutida com os professores e coordenadores dos cursos, com o objetivo de identificar primeiro quais as competências que pretendem desenvolver e identificar a metodologia que melhor se aplica. É de suma importância o alinhamento e capacitação de todo o pessoal docente para o uso de novas metodologias em sala de aula e a instituição educacional deve providenciar ações que contribuam para a implementação de novas metodologias e recursos no processo de ensino e aprendizagem.

Palavras-chave: aprendizagem baseada em projetos; projetos integradores; ensino da engenharia.

1 Introdução

O uso de metodologias ativas de aprendizado está sendo discutido cada vez mais por instituições de ensino superior no Brasil e no mundo. Os avanços tecnológicos e o perfil diferenciado dos novos alunos são algumas das razões pelas quais muitas instituições estão repensando seus processos de ensino e de aprendizagem. Neste contexto, o uso de metodologias ativas em cursos de engenharia, tem sido objeto de constantes discussões e questionamentos por parte dos docentes e instituições. Os desafios enfrentados pelas instituições de ensino superior estão cada vez mais relacionados ao perfil do aluno que ingressa no ensino superior, as melhorias nos processos de ensino e aprendizagem e no perfil profissional que será formado. Portanto, o uso de metodologias ativas de aprendizagem desempenham um papel fundamental na participação dos alunos e na qualidade da educação. Neste contexto, foi elaborada a seguinte questão de pesquisa: qual é o contribuição do uso de metodologias ativas de aprendizagem no contexto educacional do ensino superior em engenharia? Este artigo está estruturado da seguinte forma: primeiro uma breve apresentação do conceito de aprendizagem baseada em projetos é apresentada, em seguida é apresentada a metodologia utilizada na pesquisa que foi um estudo de caso que apresenta a aplicação da aprendizagem baseada em projetos em um curso de engenharia de produção em uma instituição brasileira e, finalmente, as conclusões.

2 Project Based Learning

O *Project Based Learning* é considerada uma metodologia ativa de aprendizagem que coloca o aluno no centro do processo de aprendizagem, identificando um potencial problema que pode ser resolvido através de um projeto (Lima et al., 2014). Masson et al. (2012) propõe que a aprendizagem baseada em projetos é uma abordagem sistêmica, que envolve os alunos na aquisição de conhecimentos e competências por meio de um processo de investigação de questões complexas, tarefas autênticas e produtos, cuidadosamente planejadas com vista a uma aprendizagem eficiente e eficaz.

A aplicação de projetos interdisciplinares nos primeiros semestres dos cursos de gradução possibilitam um maior engajamento por parte dos estudantes, bem como uma maior motivação para os estudos (Koch et al., 2016). As práticas de aprendizagem proporcionadas pela aprendizagem baseada em projetos vem sendo alvo de estudos e demonstram os benefícios da aplicação para os estudantes. (DeFillippi, 2001).

3 Metodologia

A metodologia presente neste artigo é um estudo de caso que visa apresentar uma visão geral da aplicação da Aprendizagem Baseada em Projetos através de projetos integradores como uma metodologia *hands-on* para o desenvolvimento de competências. A metodologia *hands-on* é derivada dos princípios da teoria construtivista de Jean Piaget na qual atribui aos estudantes o papel de construtores do próprio conhecimento (Freire & Prado, 1996). Os projetos integradores vem sendo aplicados as turmas do curso de Engenharia de Produção desde o ano de 2015 como uma ação voltada a integração de conhecimentos e práticas de diversas disciplinas a cada semestre.

O projeto integrador relatado neste estudo, que teve como temática o desenvolvimento de produtos do setor moveleiro, foi aplicado na turma do 5 semestre de 2017 do curso de Engenharia de Produção do Centro Universitário Toledo Araçatuba, UNITOLEDO, localizado na cidade de Araçatuba, estado de São Paulo, Brasil. As disciplinas envolvidas no projeto integrador fazem parte da grade curricular do 5 semestre de Engenharia de Produção, exceto a disciplina Design de Interiores que pertence ao curso de Design de Interiores da mesma instituição e que colaborou em uma etapa do projeto, auxiliando os grupos na elaboração dos desenhos dos novos produtos.

O método utilizado para a coleta dos dados destinado a demonstrar a expectativa e percepção dos alunos, e consequentemente o desenvolvimento das competências definidas para o projeto, foi um levantamento elaborado em duas partes: no início do projeto com o objetivo de colher as expectativas dos alunos e ao final do projeto com o objetivo de colher as percepções dos alunos, podendo-se comparar e avaliar os resultados. Em cada uma destas etapas os alunos avaliaram cada uma das competências de acordo com 5 níveis de desenvolvimento: 1. Ser experimentado ou exposto a...; 2. Ser capaz de participar e contribuir para...; 3. Ser capaz de compreender e explicar...; 4. Ser hábil na prática ou aplicação a...; 5. Ser capaz de liderar ou inovar em..., sendo 1 o menor nível de desenvolvimento e 5 o maior nível de desenvolvimento.

Elaborou-se também ao final do projeto uma discussão entre todos os grupos e o docente responsável pelo Projeto Integrador onde pode-se compartilhar as expectativas e percepções ao longo do projeto.

4 Estudo de Caso

O curso de Engenharia de Produção do Centro Universitário Toledo Araçatuba – UNITOLEDO, localizado na cidade de Araçatuba, estado de São Paulo – Brasil, foi lançado no ano de 2013, após um levantamento feito na região sobre a demanda por profissionais qualificados para atuarem na indústria regional.

A aplicação da Aprendizagem Baseada em Projetos relatado neste estudo ocorreu no primeiro semestre de 2017, na época, com a turma do 5 semestre através de um Projeto Integrador, desenvolvido ao longo do semestre, que teve como principais objetivos: a integração entre as disciplinas do referido semestre, a utilização de uma metodologia *hands-on* na qual foi utilizada a Aprendizagem Baseada em Projetos e o desenvolvimento de competências, além da integração ocorrida com outro curso da instituição, Design de Interiores, que auxiliou nos desenhos dos novos produtos.

O quadro 1 abaixo apresenta as competências propostas para o desenvolvimento ao longo do projeto integrador.

Quadro 1. Competências a serem desenvolvidas no projeto integrador.

COMPETÊNCIAS E ATRIBUTOS PESSOAIS E PROFISSIONAIS **(a desenvolver)**	**Raciocínio de Engenharia e Resolução de Problemas** (Identificação e formulação do problema por modelos, estimativas, análises e recomendação de soluções)
	Experimentação e Descoberta do Conhecimento (Formulação e testes de Hipóteses, levantamento da literatura eletrônica, experimentos)
	Pensamento Sistêmico (Holístico, visão do todo, urgência, priorização, foco, trade-offs e equilíbrio na resolução)
	Habilidades e atitudes PESSOAIS (Iniciativa e vontade de assumir riscos, perseverança e flexibilidade, criativo, crítico , gestão de tempo e de recursos)
	Habilidades e atitudes PROFISSIONAIS (Comportamento ético, íntegro, responsável, atualização contínua, planejamento pró-ativo para a carreira)
COMPETÊNCIAS INTERPESSOAIS **(a desenvolver)**	**Trabalho em Equipe** (Formação de Equipes Eficazes em liderança, operação técnica de maneira evolutiva)
	Comunicação (Estratégia e estrutura por meio da escrita, oral, gráfica e inter-pessoais)

Fonte: Elaborado pelos autores (2017)

O professor responsável por conduzir o Projeto Integrador foi o professor da disciplina denominada Planejamento e Gestão de Produtos, que possui como objetivo principal apresentar a teoria e prática do desenvolvimento de novos produtos de diversos segmentos industriais. As demais disciplinas participantes do Projeto Integrador, que fazem parte do semester letivo do quinto semestre de Engenharia de Produção, e suas contribuições podem ser observadas no quadro 2 abaixo.

Quadro 2. Disciplinas participantes do Projeto Integrador.

DISCIPLINAS	**CONTRIBUIÇÃO**
Planejamento Estratégico e Estratégias de Produção	Determinar a estratégia da empresa do setor moveleiro, como visão, missão e valores assim como público-alvo e estratégias de produção.
Planejamento e Gestão de Produtos	Disciplina Base para a realização do Projeto Integrador. Os alunos irão desenvolver um novo produto através das etapas do Processo Desenvolvimento Produto.
Tecnologia de Materiais	Analisar as características dos materiais para auxiliar na escolha dos materiais para o desenvolvimento do novo produto.
Resistência dos materiais I	Auxiliar na análise dos materiais para a construção do novo produto.
Processo de Fabricação e Construção I	Auxiliar na construção do protótipo em tamanho real do novo produto desenvolvido.
Design de interiores (curso de design de interiores)	Auxiliar na elaboração dos desenhos dos novos produtos.

Fonte: Elaborado pelos autores (2017).

Como temática para a aplicação da Aprendizagem Baseada em Projetos, foi escolhido o segmento moveleiro, onde os alunos, divididos em equipes de 5 integrantes deveriam desenvolver estantes para atender a uma demanda de um dos laboratórios do próprio curso da instituição.

A utilização de metodologias ativas de aprendizagem no curso de Engenharia de Produção vem sendo discutida pelo colegiado do curso, que reúne o coordenador do curso, professores e um representante dos alunos. O docente responsável pela disciplina que conduziu o projeto ao longo do semestre, realizou algumas reuniões com os demais docentes do referido semestre a fim de apresentar a proposta e buscar contribuições das demais disciplinas para o projeto que foi desenvolvido. As etapas do projeto integrador tiveram como base os princípios do *framework* CDIO, conforme relatam Edström & Kolmos (2014), e podem ser visualizadas no quadro 3 abaixo:

Quadro 3. Etapas de desenvolvimento do projeto.

ETAPA CDIO	**PRINCIPAIS AÇÕES E ENTREGAS**
CONCEIVE	1- Geração do conceito (termo de abertura do projeto) 2- Planejamento do Projeto (escopo projeto, escopo produto)
DESIGN	3- Projeto Informacional (QFD) 4- Projeto Conceitual (EAP, BOM) 5- Projeto Detalhado (Maquete, FMEA, Desenhos)
IMPLEMENT	6- Preparação para a Produção (custo, processo, protótipo em tamanho real)
OPERATE	7- Lançamento do Produto (marketing) 8- Acompanhar Produto/Processo (desempenho produto e satisfação cliente) 9- Planejar descontinuação do Produto

Fonte: Elaborado pelos Autores (2017).

As maquetes e os protótipos em tamanho real dos produtos foram fabricados no Laboratório de Práticas Produtivas II do curso de Engenharia de Produção e são apresentados na Figura 1 abaixo.

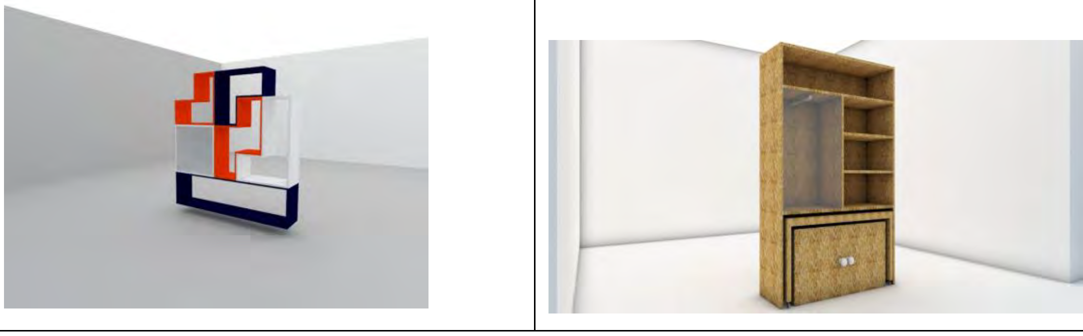

Figura 1. Produtos desenvolvidos no Projeto Integrador. Fonte: Elaborado pelos Autores (2017).

De acordo com o método de coleta dos dados destinado a demonstrar a expectativa e percepção dos alunos, e consequentemente o desenvolvimento de competências, o quadro 4 abaixo apresenta os dados coletados dos 18 alunos participantes do projeto, no início do projeto com o objetivo de colher as expectativas dos alunos. O quadro demonstra a quantidade de respostas em cada um dos níveis de desenvolvimento da referida competência.

Quadro 4. Dados coletados com a expectativa dos 18 alunos antes do projeto.

COMPETÊNCIAS	Ser experimentado ou expostos a ..	Ser capaz de participar e contribuir para ..	Ser capaz de compreender e explicar ..	Ser hábil na prática ou aplicação a..	Ser capaz de liderar ou inovar em ..
HABILIDADES E ATITUDES: PESSOAIS E PROFISSIONAIS					
Raciocínio de Engenharia e Resolução de Problemas (Identificação e formulação do problema por modelos, estimativas, análises e recomendação de soluções)	10	3	2	2	1
Experimentação e Descoberta do Conhecimento (Formulação e testes de Hipóteses, levantamento da literatura eletrônica, experimentos)	7	3	3	5	
Pensamento Sistêmico (Holístico, visão do todo, urgência, priorização, foco, trade-offs e equilíbrio na resolução)	6	6	3	3	
Habilidades e atitudes PESSOAIS (Iniciativa e vontade de assumir riscos, perseverança e flexibilidade, criativo, crítico , gestão de tempo e de recursos)	8	3	5	2	
Habilidades e atitudes PROFISSIONAIS (Comportamento ético, íntegro, responsável, atualização contínua, planejamento pró-ativo para a carreira)	3	9	2	4	
HABILIDADES INTERPESSOAIS: COMUNICAÇÃO E EQUIPE MULTIDISCIPLINAR					
Trabalho em Equipe (Formação de Equipes Eficazes em liderança, operação técnica de maneira evolutiva)	2	7	9		
Comunicação (Estratégia e estrutura por meio da escrita, oral, gráfica e inter-pessoais)	8	3	5	2	

Fonte: Elaborado pelos Autores (2017)

Ao final do projeto foram coletados novamente os dados com o objetivo de colher as percepções dos alunos, onde nota-se uma evolução pelo total de alunos que demonstraram um maior nível de proficiência após a realização do projeto. Os dados obtidos podem ser visualizados no quadro 5 abaixo.

Quadro 5. Dados coletados com a percepção dos 18 alunos após o projeto.

COMPETÊNCIAS	Ser experimentado ou expostos a ..	Ser capaz de participar e contribuir para ..	Ser capaz de compreender e explicar ..	Ser hábil na prática ou aplicação a..	Ser capaz de liderar ou inovar em ..
HABILIDADES E ATITUDES: PESSOAIS E PROFISSIONAIS					
Raciocínio de Engenharia e Resolução de Problemas (Identificação e formulação do problema por modelos, estimativas, análises e recomendação de soluções)			2	7	9
Experimentação e Descoberta do Conhecimento (Formulação e testes de Hipóteses, levantamento da literatura eletrônica, experimentos)			3	12	3
Pensamento Sistêmico (Holístico, visão do todo, urgência, priorização, foco, trade-offs e equilíbrio na resolução)		1	3	7	7
Habilidades e atitudes PESSOAIS (Iniciativa e vontade de assumir riscos, perseverança e flexibilidade, criativo, crítico , gestão de tempo e de recursos)		1	1	4	12
Habilidades e atitudes PROFISSIONAIS (Comportamento ético, íntegro, responsável, atualização contínua, planejamento pró-ativo para a carreira)	1		1	6	10
HABILIDADES INTERPESSOAIS: COMUNICAÇÃO E EQUIPE MULTIDISCIPLINAR					
Trabalho em Equipe (Formação de Equipes Eficazes em liderança, operação técnica de maneira evolutiva)		1		9	8
Comunicação (Estratégia e estrutura por meio da escrita, oral, gráfica e inter-pessoais)	1	1	3	8	5

Fonte: Elaborado pelos Autores (2017)

5 Conclusão

Com a aplicação do *project based learning* através do projeto integrador aplicado em uma turma de alunos do curso de Engenharia de Produção, pode-se identificar uma evolulção dos alunos que se auto avaliaram em dois momentos da aplicação do projeto, visto que na segunda avaliação feita ao final do projeto o nível de proficiência das competências tiveram um peso maior do que a primeira avaliação feita antes do início do projeto.

Quanto à avaliação do processo educacional que foi discutida entre os professors que ministraram as disciplinas integrantes do projeto, a aplicação do *project based learning* possibilitou integrar os conteúdos de boa parte das disciplinas do referido semestre, levando o assunto da multidisciplinaridade nas discussões dos grupos de estudantes.

O caso apresentado neste artigo demonstra a contribuição que as metodologias ativas de aprendizagem podem proporcionar a melhoria do processo de ensino e de aprendizagem, de acordo com as informações obtidas nas coletas de dados com os alunos. Um fator muito importante e que tem sido objeto de dúvidas no ensino superior, particularmente em cursos de engenharia, é precisamente o modo de aplicar a prática, juntamente com a teoria exposta na sala de aula. Outra questão é o desenvolvimento de habilidades comportamentais como liderança, trabalho em equipe e resolução de conflitos, que são tão importantes quanto as habilidades técnicas e o uso de metodologias ativas de aprendizagem fornecem apoio a esse desenvolvimento, gerando melhores resultados no processo de ensino e aprendizagem.

A aplicação de novos métodos de ensino e aprendizagem deve ser amplamente discutida com professores e coordenadores de cursos, a fim de identificar primeiro quais habilidades eles pretendem desenvolver e como identificar qual metodologia é melhor aplicada. O alinhamento e treinamento de todo o corpo docente para o uso de novas metodologias na sala de aula é extremamente importante e a instituição educacional deve fornecer ações que contribuam para a implementação de novas metodologias e recursos no processo de ensino e aprendizagem. A experiência adquirida na aplicação de aprendizagem baseada em projetos trouxe resultados satisfatórios, o que permitiu várias discussões entre professores e coordenador de curso na metodologia para aplicação nos próximos semestres e também para sua aplicação em outros cursos de engenharia da instituição. Pesquisas adicionais devem ser feitas para identificar o perfil do aluno que entra no ensino superior, a fim de avaliar a mudança de paradigma e o problema do abandono escolar e como o uso de metodologias de aprendizagem ativa pode contribuir positivamente para essas questões.

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A proposal based on active methodologies for leveling in mathematics for students enrolled in engineering courses

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Abstract

Evasion is a problem in engineering courses: on average, 41% of students leave the course, and most of them in the first two semesters. Among the factors mentioned in the literature as cause of this phenomenon, one of the most cited is the knowledge gap in the area of mathematics. To help these students, who unfortunately today are the vast majority, many engineering courses have been creating mathematics grading disciplines. This paper presents a proposal where, instead of lectures, the students work in autonomous groups, addressing only the subjects where they presented difficulties. The content of this discipline encompasses contents of middle and high school, divided into 27 modules. Students initially go through a diagnostic test to see where they have gaps. Then they join in groups according to their interests to solve exercises proposed especially for this purpose. Each exercise has associated with it, an explanatory video and an indication of where you can consult the handout for questions. In the classroom, the students are assisted by a facilitator teacher and 2 T.A.s to assist them in their doubts. Every 4 classes, students take assessment tests, where they can eliminate up to 3 modules at a time. If they fail at one, they will have another chance in the next evaluation cycle. The idea is that each one will develop at its own pace, filling its own gaps. Due to the large number of exercises and tests lists, we chose to use a virtual learning platform, Moodle. Thus, in addition to the teachers and monitors, it also required human resources in the area of IT. This paper describes the motivations for this choice, the care at the time of implementation, the resources needed and the first results of this initiative.

Keywords: Active Learning; adaptive learning platforms; leveling; freshmen.

Uma proposta baseada em metodologias ativas para nivelamento em matemática para ingressantes em cursos de engenharia

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Resumo

A evasão é um problema em cursos de engenharia: em média, 41 % dos alunos deixa o curso, e a maior parte deles, nos primeiros dois semestres. Dentre os fatores apontados na literatura como causa deste fenômeno, um dos mais citados é a lacuna de conhecimentos na área de matemática. Para ajudar estes alunos, que infelizmente hoje são a grande maioria, muitos cursos superiores de engenharia vêm criando disciplinas de nivelamento em matemática. Este trabalho apresenta uma proposta onde, ao invés de aulas expositivas, os alunos trabalham em grupos autônomos, abordando apenas os assuntos onde tenham apresentado dificuldades. O conteúdo desta disciplina é o de primeiro e segundo graus, divididos em 27 módulos. Os alunos passam inicialmente por um teste diagnóstico para verificar onde apresentam lacunas. Depois, juntam-se em grupos de acordo com os interesses de conteúdo, e resolvem então exercícios propostos especialmente para este fim. Cada exercício tem a ele associado, um vídeo explicativo e uma indicação de onde pode consultar a apostila, para tirar dúvidas. Na sala de aula, os alunos contam com o auxílio de um professor facilitador e 2 monitores para auxiliá-los em suas dúvidas. A cada 4 aulas, os alunos fazem testes avaliativos, onde podem eliminar até 3 módulos de cada vez. Se forem reprovados em algum, terão outra chance no próximo ciclo de avaliações. A ideia é que cada um vá se desenvolvendo em seu próprio ritmo, preenchendo as suas próprias lacunas. Devido ao grande número de listas de exercícios e provas, optou-se por utilizar uma plataforma de aprendizagem virtual, o Moodle. Assim, além dos professores e monitores, foram necessários também recursos humanos na área de TI e de informática. Este trabalho descreve as motivações para esta escolha, os cuidados na hora da implementação, os recursos necessários e os primeiros resultados desta iniciativa.

Palavras chave: Aprendizagem ativa, plataformas adaptativas de aprendizagem, nivelamento, alunos ingressantes.

1 Introdução

As políticas de democratização de acesso ao ensino superior permitiram que um grande número de pessoas, antes excluídas desta etapa da formação, pudessem entrar em uma universidade ou faculdade. (Catani, Hey & Gilioli, 2006). Com isto, as universidades, notadamente as privadas, deixaram de ser instituições da elite para as elites, e passaram a receber alunos de classes menos favorecidas (Almeida, 2007).

Estes novos alunos têm um perfil diferente daqueles que até então conseguiam ingressar no ensino superior. Os alunos "tradicionais" vêm em geral de famílias com bons recursos financeiros, e têm uma boa formação acadêmica. Por outro lado, muitos dos "novos" alunos pertencem à primeira geração que conseguiu ingressar no ensino superior, têm que trabalhar para se sustentar, tem pouco tempo para estudar, e em geral possui muitas lacunas em seu repertório acadêmico (Almeida et al, 2012).

Este fenômeno vem causando um aumento no índice de evasão: para a área de engenharia por exemplo, em média, 41 % dos alunos abandona seu curso, e a maior parte deles, nos primeiros dois semestres (Testezlaf, 2010). Além da origem dos alunos, há várias outras causas apontadas pela literatura para este fenômeno, tanto no ambiente interno como no ambiente externo das instituições, além de aspectos relacionados a questões pessoais do próprio aluno (Davok & Bernard, 2006).

No contexto deste trabalho, as causas internas à IES são as de maior interesse, pois é onde podemos atuar. Dentre elas, são citadas na literatura: o ambiente desfavorável ao aprendizado e professores desqualificados. O primeiro fator diz respeito às acomodações físicas da IES, tais como biblioteca, laboratórios e salas de aula.

Em relação aos professores, são listados a falta de formação pedagógica, sistema de avaliação inadequado e o não reconhecimento das dificuldades de aprendizagem do aluno (Davok & Bernard, 2006).

Este trabalho apresenta uma proposta de endereçamento destes fatores através de uma disciplina introdutória de nivelamento de matemática onde, ao invés de aulas expositivas, os alunos trabalham em grupos autônomos, abordando apenas os assuntos onde tenham apresentado dificuldades. São descritas as motivações para esta escolha, os cuidados na hora da implementação, os recursos necessários e os primeiros resultados desta iniciativa.

2 Motivações

Há alguns anos verifica-se que uma grande porcentagem dos alunos ingressantes em nossa instituição apresentava grande dificuldade principalmente em conteúdos relacionados à matemática. Isto também foi percebido por outras instituições de ensino na área de engenharia, que passaram a ofertar, assim como nós, um curso de nivelamento em matemática (Frescki & Pigatto, 2009).

Este curso foi proposto inicialmente como uma disciplina em um modelo de aula tradicional, ministrada por monitores, com 2 aulas semanais, e 2 provas ao longo do semestre. Este modelo vigorou por 2 anos, e não surtiu os efeitos desejados.

Dentre as razões apontadas à época para este resultado foram o fato de as aulas serem ministradas por monitores e a percepção dos alunos de que se soubessem uma parte do conteúdo, passavam a achar que sabiam todo o conteúdo, e desta forma, deixando de levar a sério as aulas. Muitos alunos também relataram o seu desapontamento em estudar conteúdos de primeiro e segundo graus ao ingressarem em um curso superior, quando sua expectativa era de aprender conceitos mais avançados.

Desta forma, este modelo não se mostrou adequado. Ficou evidente que era necessário um novo modelo, que atendesse à diversidade das necessidades de aprendizagem de um grupo extremamente heterogêneo de alunos, tanto de lacunas de conteúdo como de formas de aprendizagem.

Dentre as opções elencadas como alternativa para o modelo tradicional de ensino, optou-se pelo uso de plataformas adaptativas de aprendizagem, um conceito muito comum em cursos de EaD (Brusilovsky, 2003). Na seção seguinte, esta metodologia é descrita com mais detalhes.

3 Plataformas adaptativas de aprendizagem

As plataformas adaptativas de aprendizagem são ambientes virtuais que idealmente entregam a cada aluno um plano de trabalho personalizado de acordo com suas necessidades (Geyer et al, 2001).

Há várias formas de implementar tais ferramentas, mas todas elas compartilham a mesma ideia básica: a criação de um modelo do aluno e um modelo do conteúdo para definir o plano de trabalho para cada aluno (Brusilovsky, 2003). O modelo do aluno é construído a partir de seus conhecimentos do conteúdo, suas competências e habilidades, e o modelo do conteúdo é formado pelo conjunto de conhecimentos que ele deve dominar ao término do curso.

As diferentes estratégias utilizadas para gerar o modelo do aluno e o plano de trabalho individual é que diferenciam as diversas plataformas disponíveis. A maioria delas segue um modelo simples de provas diagnósticas para determinação do modelo do aluno e do plano de trabalho, enquanto outras plataformas fazem uso de técnicas de inteligência artificial para inferir lacunas não tão evidentes (Freedman, 2000), (Matsuda & Okammoto, 1992).

Uma questão importante a se observar no uso de tais sistemas é a criação de interfaces de software que sejam voltadas ao perfil dos usuários: estas devem observar aspectos tanto do processo de aprendizagem dos alunos, como também do processo de mediação do professor. Ainda, funcionalidades muito rígidas ou pouco adaptativas podem tornar um ambiente por demais diretivo e inadequado aos professores e suas práticas. (Gomes, Tedesco & Castro-Filho, 2003).

Há várias plataformas disponíveis no mercado (Bopprê, 2016), mas optamos por desenvolver a nossa própria, tanto por motivos de custo como também para aprender mais sobre o processo e ter maior controle e liberdade para eventuais modificações que julgássemos necessárias.

Na seção a seguir a proposta metodológica para esta disciplina será descrita em detalhes.

4 Proposta metodológica

Nesta seção são apresentados os objetivos da disciplina e a forma como os implementamos no dia a dia da sala de aula, bem como os critérios de avaliação adotados.

4.1 Objetivos da disciplina

Segundo o plano de ensino da disciplina, o curso de nivelamento em matemática tem por objetivo: "Proporcionar ao aluno uma revisão e um aprofundamento de alguns conceitos matemáticos (aritméticos e algébricos) que compõem o programa do ensino fundamental e médio. Esses conceitos são ferramentas fundamentais para um bom entendimento de várias outras disciplinas, em especial das disciplinas de Cálculo e de Física. A disciplina objetiva também ser um espaço propício para o desenvolvimento do raciocínio lógico, da capacidade de análise e da visão sistêmica dos alunos. Análise de gráficos. Situações problema."

Os conteúdos abordados são: potenciação, radiciação, expressões e operações algébricas, fatoração, polinômios, equações e inequações, funções, matrizes e determinantes, sistemas de equações e números complexos, divididos em 27 módulos.

4.2 Procedimentos de ensino

Esta disciplina tem carga horária total de 80 horas, com 2 encontros semanais de 2 horas cada.

Inicialmente é realizada uma avaliação diagnóstica para identificar as lacunas de cada aluno. Como o conteúdo é muito extenso, optou-se por fazer esta avaliação apenas com o conteúdo dos 4 primeiros módulos, cujos assuntos são potenciação, radiciação e expressões e operações algébricas. Se os alunos mostrarem domínio destes assuntos, então os mesmos já são eliminados de seu plano de estudos.

Depois disso, o andamento dos trabalhos segue vários ciclos, onde cada ciclo é dividido em uma etapa de estudos e uma etapa de avaliação somativa.

Na etapa de estudos, os alunos, em grupos, trabalham os conteúdos dos módulos que ainda não conseguiram eliminar. Nestas aulas, ele deve resolver listas de exercícios, com a ajuda de apostilas, livros, acesso à Internet, consulta aos colegas, monitores e professores. Esta etapa dura 3 aulas.

A próxima aula é dedicada à etapa de avaliação somativa, e nesta os alunos podem realizar provas de até 4 módulos à sua escolha. Cada aluno pode repetir as avaliações de um dado módulo quantas vezes quiser, até conseguir ser aprovado. Assim, a cada etapa de avaliação, o aluno consegue eliminar mais alguns módulos, e o ciclo se repete, agora para os módulos remanescentes.

Esta estratégia permite que cada aluno se dedique às suas próprias lacunas, avançando de acordo com seu próprio ritmo.

4.3 Avaliação

Para cada módulo é preparada uma prova de múltipla escolha com 5 questões, sendo que cada questão tem 5 alternativas. Para que um módulo seja validado, o aluno deve conseguir 60 pontos em 100, ou seja, deve acertar pelo menos 3 questões. Se o seu desempenho for pior que isso, será computada uma nota igual a 0.

Ao final do semestre é calculada uma média aritmética simples dos 27 módulos, e os alunos que obtiverem uma nota acima de 60 pontos são considerados aprovados.

O esquema de avaliação proposto permite que cada aluno faça várias tentativas para um determinado conteúdo e avance segundo seu próprio ritmo, mas exige a preparação e a correção de pelo menos 27 provas por turma a cada ciclo de avaliação. Este é um trabalho insano para ser realizado da forma tradicional, e desta forma, optamos por usar um LMS (*Learning Management System*) para esta tarefa. O sistema escolhido foi o Moodle, pois este já estava sendo utilizado em nossos cursos de EaD, de forma que já havia expertise instalada em nossa instituição.

Na próxima seção iremos mostrar como isto foi feito, bem como os demais recursos físicos utilizados.

5 Infraestrutura

Iremos agora descrever os ambientes físicos para as aulas, bem como a construção das listas de exercícios e o sistema de construção e correção das provas.

5.1 Salas de aula

Em geral, para desenvolver atividades envolvendo metodologias ativas não são necessárias salas de aula especiais; basta apenas que seja possível realizar trabalhos em grupo, e, portanto, salas em forma de auditório a princípio não seriam adequadas, embora não seja impossível trabalhar nelas.

Em nossa instituição, entretanto, foram construídas 4 salas de aula, com capacidade para 60 alunos cada, especialmente projetadas para atividades envolvendo metodologias ativas. As principais características destas salas são:

- As paredes foram recobertas por uma película onde é possível escrever com canetas para quadro branco, e assim os alunos podem usá-las pra discussões em grupo; também há painéis espalhados pela sala para que os grupos que não estejam perto das paredes possam fazer uso deles para o mesmo fim.
- Cada sala conta com um rack contendo 25 notebooks para que os alunos possam utilizar softwares de simulação, fazer consultas na Internet, e acessar a plataforma Moodle, onde estão as listas de exercícios e as provas.
- Há 3 projetores em cada ambiente, de modo que quando os alunos estão sentados em grupos, não tenham que ficar se virando para visualizar alguma projeção que o professor esteja mostrando.
- As salas estão posicionadas de forma contígua, duas a duas, separadas por uma estrutura acústica que pode ser aberta. Desta forma, é possível realizar atividades com 60 ou 120 alunos, dependendo da necessidade.
- O *access point* para cada sala também teve que ser dimensionado de forma a suportar não apenas a banda de transmissão, mas também a densidade de conexões simultâneas, pois além dos notebooks, é normal que cada aluno conecte também seu aparelho celular à rede Wi-Fi.

5.2 Moodle

O Moodle (*Modular Object-Oriented Dynamic Learning Environment*) é uma plataforma de aprendizagem projetada para oferecer a educadores, administradores e aprendizes um sistema para criar ambientes de aprendizagem personalizados (Moodle, s.d.). É um software de código aberto, que pode ser instalado em qualquer computador ou servidor que execute PHP e comporte uma base de dados SQL.

Esta apresenta diversos recursos para o ambiente educacional, tais como a disponibilização de conteúdo, fóruns, *wikis*, calendários, notificações, ferramentas para avaliação, dentre vários outros. Para este curso foram utilizados os recursos de disponibilização de conteúdo (documentos eletrônicos e vídeos) e o de avaliação.

Como o Moodle iria ser usado tanto para a etapa de estudos como para a de avaliação, optamos por fazer duas instalações independentes, em dois servidores distintos: um para as provas (Moodle Interno) e outro para as listas de exercícios (Moodle Externo).

O Moodle Interno armazena as questões das provas, e o acesso a ele só é possível dentro do Inatel, quando os dispositivos (computadores, notebooks ou celulares) estiverem conectados à uma rede WiFi específica. Esta rede não permite o acesso a qualquer outra página web que não seja à do Moodle Interno.

O Moodle Externo contém as listas de exercícios, e fica hospedada em um servidor que permite acesso externo. Os alunos podem navegar pela plataforma de qualquer dispositivo conectado à internet. Assim, os alunos podem estudar tanto em casa quanto em sala de aula em qualquer hora do dia.

Ambos os servidores apresentam as mesmas configurações básicas: processador Intel Xeon E5-2650 v3 @2.3 GHz Quad Core, sistema operacional Linux Debian 8.1 e HD SATA 6.0 Gbps com 80 GB. A diferença entre eles, está no tamanho da memória RAM de cada um, o servidor interno tem 4GB (1 x 4 GB DDR3 1333 MHz), já o externo tem o dobro desta memória.

5.3 Listas de exercícios e provas

Para cada módulo foi criada uma lista de exercícios com aproximadamente 20 questões. A seleção destes exercícios é crítica, pois devem cobrir todo o conteúdo e também devem estar organizados em uma ordem tal que permita a compreensão gradual do mesmo. Ao final, exercícios de extensão e contextualização também devem ser inseridos para verificar se o aluno consegue generalizar os conceitos e também aplicá-los em situações problema. Os exercícios iniciais, de assimilação do conteúdo, contam com links para vídeo aulas e indicações para páginas específicas para a apostila do curso para ajudar os alunos.

As provas são montadas a cada ciclo pelos professores, a partir de um banco de questões hospedado no Moodle Interno. A criação deste banco é fundamental para a metodologia escolhida, pois seria inviável criar 27 provas a cada período de 2 semanas. Diversos recursos foram utilizados para alimentar este banco de dados com mais de mil questões. Estas foram coletadas a partir de livros, apostilas antigas e páginas da Internet. Também foi adquirido um banco de questões comercial, o Super Professor (www.sprweb.com.br), cuja versão pro possui mais de 129.000 questões de 11 disciplinas distintas. Ao aplicar filtros por assunto e grau de dificuldade, as provas são facilmente elaboradas.

5.4 Recursos humanos

Para cada turma foi designado um professor e 2 monitores, selecionados através de edital entre os alunos de graduação. Como cada turma tem em média de 40 a 45 alunos, tem-se aproximadamente um facilitador para cada 13 a 15 alunos. Estes receberam um breve treinamento prévio sobre facilitação em metodologias ativas antes de iniciarem as atividades em sala de aula.

Além da preparação do material e das provas, o corpo docente se reúne por uma hora, uma vez por semana, para discutir o andamento das atividades e propor alternativas e soluções para os problemas encontrados.

Além dos professores e monitores, esta disciplina contou com um estagiário para configuração, gerenciamento e manutenção da plataforma Moodle e lançamento dos resultados das avaliações no sistema da instituição, bem como um funcionário da área de TI para configuração dos servidores e especificação, monitoramento e manutenção da rede Wi Fi.

6 Análise dos resultados

Esta metodologia foi aplicada a 174 alunos, sendo 19 repetentes e os demais 155 ingressantes. Estes foram divididos em 4 turmas, tendo cada turma de 40 a 45 alunos.

Os testes diagnósticos, com provas dos 4 módulos iniciais, indicaram um rendimento bastante ruim, com mais da metade dos alunos sendo reprovados no primeiro módulo. Com este desempenho era de se esperar uma alta taxa de reprovação ao final do semestre, o que foi confirmado: 60 % dos alunos não conseguiram desempenho para serem aprovados.

Para tentar entender um pouco melhor como os alunos reagiram a esta nova metodologia, foi solicitado a eles que respondessem a um questionário, organizado na forma de afirmações, e a cada uma delas, eles deveriam indicar seu grau de concordância, segundo uma escala Likert de 4 níveis. Dos 174 alunos matriculados, 91 responderam ao questionário (52 %), e um resumo das respostas a algumas destas questões é apresentado na Tabela 1.

Tabela 22. Respostas de algumas questões submetidas aos alunos.

Afirmações	Concordo totalmente	Concordo Parcialmente	Discordo parcialmente	Discordo totalmente
A base que obtive durante minha formação no ensino médio foi suficiente para resolver as listas de exercícios.	12,1 %	33 %	18,7 %	36,3 %
A plataforma Moodle é intuitiva e de fácil utilização.	60,4 %	31,9 %	7,7 %	0 %
Esta metodologia de fazer o aluno trabalhar mais independentemente foi eficaz para o meu aprendizado.	14,3 %	42,9 %	16,5%	26,4 %
Eu prefiro esse estilo de aula ao invés da aula tradicional.	8,8 %	22 %	27,5 %	41,8 %
Eu me adaptei bem a este estilo de aula.	20,9 %	30,8 %	15,4 %	33 %
Nas aulas, eu prefiro trabalhar em grupo.	28,6 %	38,5 %	20,9 %	12,1 %
Ao terminar esta disciplina, me sinto mais preparado para enfrentar um curso de engenharia.	5,5 %	44 %	23,1 %	27,5 %
Tenho menos stress quando faço uma prova nesta matéria, em comparação com uma prova de uma disciplina tradicional.	39,6 %	25,3 %	14,3 %	20,9 %
O trabalho em grupo me ajuda a compreender a matéria, sem a ajuda dos monitores ou professores.	4,4 %	49,5 %	31,9 %	14,3 %

A partir da análise desta tabela, pode-se perceber que mais da metade dos alunos não sente que chegou ao curso de engenharia com base matemática adequada, fato corroborado pelo teste diagnóstico.

A plataforma escolhida não parece ser um problema para a maioria, embora tenham havido vários episódios de alunos que esqueceram a senha e outros problemas menores de acesso. Houve também alguns episódios esparsos de queda do servidor, mas nada que merecesse nota nos comentários tecidos pelos alunos.

A grande insatisfação ficou por conta da metodologia utilizada, por ser bem diferente do que estavam acostumados, e principalmente pelo fato de terem que assumir o protagonismo de seu aprendizado. Comentários do tipo: "eu preferia que o professor explicasse a matéria ao invés de ficar perdendo meu tempo em um grupo que não faz nada" ilustram bem este ponto. Aos facilitadores cabe então a tarefa de não apenas tirar as dúvidas dos alunos, mas garantir para que todos se engajem na tarefa a ser cumprida. Talvez uma valorização da participação em termos de nota possa ajudar neste ponto.

Percebeu-se também que os alunos formam grupos mais por afinidade pessoal do que por afinidade de assuntos a serem trabalhados. Com isto, a ajuda que poderiam obter de colegas estudando o mesmo assunto fica bastante prejudicada. É preciso mudar então a forma de formação dos grupos, com base no assunto a ser estudado.

Percebeu-se também que, para muitos, esta não é uma disciplina de revisão, mas o primeiro contato com determinados conteúdos. Isto não deveria acontecer, mas é a realidade do ensino fundamental e médio no Brasil, e temos que lidar com isso. Muitos reclamam que não conseguem aprender sozinhos estes conteúdos, e realmente é um ponto que precisa ser revisto.

Em relação às avaliações, alguns alunos passaram a "chutar" as respostas nas provas depois de um tempo, na esperança de conseguir eliminar algum módulo na sorte. Apesar de a probabilidade de sucesso ser de apenas 6 %, alguns realmente conseguiram eliminar um módulo desta forma, o que acabou encorajando mais alguns a fazerem o mesmo. Todos os alunos que disseram ter usado deste subterfúgio ao menos uma vez foram reprovados na disciplina, inclusive aqueles que conseguiram eliminar algum módulo. Apesar disso, devemos estabelecer estratégias para coibir este tipo de atitude, pois o desejado é que os alunos, além de aprenderem o conteúdo, ganhem maior independência em relação aos estudos, e ninguém consegue isto apenas chutando as respostas.

7 Conclusões

A democratização do acesso aos cursos superiores promovida pelo governo brasileiro permitiu que parte da população brasileira, antes excluída, pudesse frequentar cursos de engenharia e tecnologia. Entretanto, com um histórico não tão bom, ficou muito difícil de muitos destes ingressantes continuarem no curso (Davok & Bernard, 2006).

Na tentativa de ajudar estes estudantes, propõe-se neste trabalho um curso de nivelamento em matemática com base em metodologias ativas de aprendizagem, através do uso de plataformas adaptativas, onde cada aluno trabalha apenas nos assuntos em que tem dificuldade.

Neste trabalho foram descritos a proposta pedagógica, as necessidades e os cuidados tanto em termos físicos como humanos para implementar esta disciplina.

Ao final do semestre, apenas 40% dos alunos foi aprovado, um resultado preocupante em se tratando de uma disciplina de nivelamento. Dentre as causas apontadas para este resultado destacam-se a formação precária com que os estudantes chegam à nossa instituição e a falta de comprometimento com os estudos. Desta forma, as atividades de facilitação dos professores e monitores deve focar mais nos processos do que nos conteúdos: motivar os alunos, mostrar estratégias de estudo e cobrar deles o comprometimento nas atividades de estudo, parece ser a forma mais conveniente de lidar com esta questão.

Outro ponto de atenção é que alguns dos assuntos não foram sequer vistos por uma parcela dos alunos, e, portanto, estes necessitam de um maior auxílio. Com isso, é necessário estabelecer estratégias para ajudar a estes alunos.

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Teaching Electric Machines Using Project Based Learning Focusing in Solutions to Real Problems of Mankind

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Abstract

The aim of this paper is the dissemination of perceptions and experiences using Project Based Learning in Electric Machines classes of Electrical Engineering course at University of Brasília, Brazil. The approach analyses nine times the classes were presented, from 2013 to 2017. During the first seven times a diagnostic had been done based on in-class experience, in order to restructure the class. The following two times the PBL techniques were used. The paper presents the motivation to use PBL, the method used to redraw the class, the implementation phase, the results and a discussion about their effectiveness. PBL technique were applied to 126 students and got 99% of student's approval. The main aspects that really motivated the students to use active learning were: the emphasis in noble goals for the projects, were the student can think about engineering solution to real problems of mankind, and a classroom free from evaluation from the professor, where the students are free to present their own creative and innovative ideas.

Keywords: Active Learning; Engineering Education; Project Based Learning, Electric Machines.

Aprendizagem Baseada em Projetos Visando Atender Demandas da Sociedade Como Forma de Ensino de Máquinas Elétricas

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Resumo

O presente artigo tem como objetivo apresentar as percepções e experiências obtidas com a aplicação de Aprendizagem Orientada a Projeto na disciplina obrigatória Máquinas Elétricas do curso de graduação em Engenharia Elétrica da Universidade de Brasília (UnB). A análise apresentada compreende 9 semestres letivos, ministrados entre os anos de 2013 e 2017. Durante a oferta da disciplina para as primeiras sete turmas, adquiriu-se experiência e realizou-se um diagnóstico acerca da motivação dos alunos, buscando-se reunir os elementos necessários para reestruturar a disciplina. Nos dois semestres seguintes, foram aplicadas técnicas PBL, cujos resultados são apresentados e discutidos neste artigo. Além da motivação para aplicação de PBL, o artigo apresenta o método utilizado para reestruturar a disciplina, a descrição da fase de implementação, os resultados obtidos e a discussão da efetividade das técnicas utilizadas. A utilização de PBL abrangeu uma amostra de 126 estudantes e teve 99% de aceitação por parte dos alunos. Os pontos principais que melhoraram a motivação dos alunos e os estimularam a estudar o conteúdo de forma ativa foram: a abordagem de projetos com ênfase em metas nobres, em que os alunos atendem demandas da sociedade, fornecendo senso de propósito para o estudo, e o ambiente livre de notas, onde o aluno pôde apresentar suas ideias e seus projetos sem o receio de ser negativamente avaliado se estiver errado, fornecendo solo fértil para criatividade e soluções inovadoras.

Palavras-chaves: Aprendizagem Ativa; Educação em Engenharia; Aprendizagem Baseada em Projetos; Máquinas Elétricas.

1 Introdução

O curso de graduação em Engenharia Elétrica da Universidade de Brasília (UnB), fundado em 1967, possui duração total de 3.930 horas, com prazo para conclusão estimado em 10 semestres, sendo ofertadas 40 vagas por semestre (i.e. 80 vagas por ano). Os estudantes cursam disciplinas básicas, tais como cálculo, física, álgebra linear, estatística, e também disciplinas ofertadas por outras unidades acadêmicas, tais como ciências do ambiente, introdução à economia, introdução à sociologia e noções de direito. Por fim, conteúdos específicos são abordados, cobrindo tanto tópicos básicos da Engenharia Elétrica (e.g. circuitos elétricos) quanto disciplinas específicas, tanto obrigatórias quanto eletivas, para os alunos que desejam dar ênfase em uma das seguintes áreas de atuação: Telecomunicações, Eletrônica, Sistemas Elétricos de Potência ou Controle e Automação. A disciplina Máquinas Elétricas, com duração de 60 horas-aula, faz parte da cadeia obrigatória do curso de Graduação em Engenharia Elétrica e é ofertada aos estudantes do 7º período do curso. Ela tem como pré-requisito a disciplina Conversão de Energia, ofertada no 6º período.

Estudo realizado pelo Decanato de Ensino de Graduação da UnB em 2016 identificou que apenas 76,1% dos 29.891 ingressantes da Universidade entre 2002 e 2008 se graduaram. As estatísticas do Curso de Engenharia Elétrica estão próximos à média, visto que 74,1% dos 568 alunos que ingressaram no Curso se formaram, sendo 43,1% dentro do prazo de 5 anos e 31,0% fora do prazo (Universidade de Brasília, 2016).

É evidente que esse elevado grau de evasão observado nos cursos de graduação depende de diversos fatores. No entanto, pode-se afirmar que a motivação dos estudantes é fator essencial para garantir a continuidade e a conclusão do curso no prazo estabelecido. O investimento em técnicas didáticas motivadoras, que estimulem o estudante a concluir o curso dentro do prazo acarreta, além de satisfação pessoal para o estudante, economia para a sociedade, visto que não terminar o curso ou demorar para terminá-lo custa mais caro para a Universidade.

O presente artigo tem como objetivo apresentar as percepções e experiências obtidas com a aplicação de Aprendizagem Orientada a Projeto (*Project Based Learning* – PBL) na disciplina obrigatória Máquinas Elétricas, do curso de Engenharia Elétrica da Faculdade de Tecnologia da Universidade de Brasília. A disciplina tem carga-horária de 60 horas-aula e é cumprida em dois encontros semanais de 1h50 cada. Foram analisadas nove turmas, entre 2013 e 2017, onde foram coletadas informações que permitissem realizar um diagnóstico da motivação dos alunos, visando reestruturar a disciplina. Técnicas PBL foram aplicadas nos dois últimos semestres, cujos resultados são aqui discutidos. O artigo apresenta a motivação para aplicação de PBL, o método utilizado para reestruturar a disciplina, a descrição da fase de implementação, os resultados obtidos e a discussão da efetividade das técnicas utilizadas. Por fim, são apresentadas as conclusões.

2 Motivação

Ao longo de sete semestres, desde 2013, a disciplina foi ministrada seguindo métodos convencionais de ensino e avaliação, adotado para esta e tantas outras disciplinas do curso de Engenharia Elétrica. Nesses métodos, as aulas são expositivas, conduzidas pelo professor com base em livro texto adotado para a disciplina; e as avaliações são escritas, individuais e sem consulta, usualmente baseadas em questões que exigem muitos cálculos para as resoluções. Um acompanhamento mais minucioso do desempenho dos estudantes, da eficiência da aprendizagem e da motivação dos alunos, evidenciou vários problemas, que foram agrupados nos itens a seguir:

Os alunos estavam pouco motivados a efetivamente apreender o conteúdo que era apresentado a eles, demonstrando dificuldades em extrapolar os conceitos para situações além das apresentadas pelo professor em sala de aula, dando indícios de que aprendiam o conteúdo exclusivamente para passar nas provas, e não para aplicação em sua vida profissional. Um sinal do desinteresse foi a baixa quantidade de alunos (3%) que procuraram o professor para tirar dúvidas fora do horário de aula;

Foi identificada baixa retenção das informações ensinadas na disciplina do período anterior "Conversão de Energia", pois houve a necessidade de recapitular o conteúdo já ensinado para que os alunos pudessem acompanhar os novos elementos de Máquinas Elétricas a serem apresentados;

Por se tratar de uma disciplina com aplicação direta na área de Sistemas Elétricos de Potência, os estudantes que tinham interesse em outras áreas (Telecomunicações, Eletrônica ou Controle e Automação) não consideravam o conteúdo relevante para sua formação;

Os alunos que cursavam a disciplina e não obtinham a média mínima eram reprovados e, ao cursar novamente, continuavam com notas muito baixas;

Muitos alunos resolviam as provas de forma mecanizada, sem efetivamente analisar as questões apresentadas ou a importância dos temas tratados. Por exemplo, quando uma questão era baseada em um exercício resolvido previamente, porém com algumas alterações, muitos alunos resolveram a prova exatamente como o exercício original, indicando que decoraram uma sequência de passos, em vez de entender o problema e desenvolver um raciocínio para obter a solução adequada; e

Em uma das provas foi acrescentada uma informação adicional ao enunciado; tratava-se de um dado irrelevante, porém 50% dos alunos apresentaram dúvida sobre como resolver a questão visto que não sabiam como usar esse dado adicional, indicando insegurança na resolução da questão quando novos fatores são acrescentados.

Com base nessas percepções, decidiu-se consultar os próprios estudantes que estavam cursando a disciplina sobre como melhor aproveitar o conteúdo ministrado. Muitos não se manifestaram, demonstrando surpresa com o questionamento, enfatizando a postura passiva de aprendizado, onde o aluno pouco interage com o professor. No entanto, alguns alunos que participaram do programa "Ciências Sem Fronteiras" relataram as boas práticas de suas experiências no exterior. Foram unânimes em relatar que tiveram muitas disciplinas baseadas em projetos, e que aprenderam mais nesse formato do que com aulas expositivas. Esse diálogo professor-estudantes foi realizado durante dois semestres consecutivos. A análise dessas informações evidenciou que os estudantes estavam receptivos e até entusiasmados com a introdução de novas técnicas de ensino-aprendizagem e, notadamente, aquelas baseadas em PBL. Assim, decidiu-se introduzir e testar técnicas de PBL na disciplina, incluindo novas formas de avaliação, visando principalmente motivar os alunos a estudar mais profundamente o conteúdo da disciplina.

3 Método

A aplicação de PBL em engenharia é um assunto discutido por diversos autores, que apresentam experiências e desafios (Dunai & Fajarnés, 2017; Kumar & Radcliffe, 2017; Nwokeji & Frezza, 2017; Rekola & Messo, 2017). Reis (2017) apresenta um resumo do estado-da-arte e do desenvolvimento de PBL em cursos de engenharia no Brasil, com destaque para o desafio de mudar da linha tradicional de ensino, onde o professor é o centro e as aulas são expositivas, para um ambiente onde tanto os estudantes quanto os professores são protagonistas, criando espaço para o desenvolvimento das competências desejadas. Tal mudança exige esforço do meio acadêmico para retirar professores e alunos de suas zonas de conforto.

A técnica PBL já havia sido utilizada anteriormente para o ensino de Máquinas Elétricas na Universidade de Brasília. A disciplina optativa "Projeto Integrador", ofertada pelo Departamento de Engenharia Mecânica, reuniu, entre 2010 e 2016, alunos de diferentes cursos, cursando semestres variados para, juntos, projetarem um veículo elétrico para auxiliar na coleta seletiva de resíduos dentro do Campus da Universidade de Brasília. Tal projeto reuniu alunos das Engenharias Mecânica, Elétrica, de Energia, Automotiva, Mecatrônica e Produção, que viram-se motivados a fazer um projeto de engenharia de cunho social, haja vista que o resultado auxiliaria na coleta de material reciclável, utilizaria veículo com motor elétrico e ajudaria a reduzir desigualdades sociais, uma vez que aumentaria a renda das cooperativas de catadores que atuavam no Campus (Viana, Silva, Garrossini, Maranhão & Abdalla Junior, 2011) (Azevedo, Almeida, Oliveira & Orrico, 2012) (Viana, Maranhão, Azevedo, Shayani, Garrossini & Abdalla Junior, 2012) (Viana, Maranhão, Garrossini, Abdalla Junior, Molinaro & Brasil Junior, 2013).

Com base na experiência adquirida e nos resultados obtidos, elaborou-se a reformulação da técnica de ensino-aprendizagem, que seguiu as etapas descritas a seguir: identificação dos fatos, identificação dos princípios norteadores, definição da ação, implementação e reflexão.

Identificação dos fatos: Os fatos e as percepções obtidas pelo professor já foram listados na seção anterior. Eles podem ser resumidos como: baixa motivação por parte dos alunos, dificuldade em extrapolar o conteúdo para aplicações diferentes, baixa retenção do conteúdo da disciplina anterior (pré-requisito), impressão de que o conteúdo não é relevante para sua formação e falta de segurança na resolução de exercícios.

Identificação dos princípios norteadores: Essa etapa gerou uma profunda reflexão sobre o papel do professor e o que se deseja desenvolver nos alunos. Houve o entendimento de que o professor não é mais a fonte de conhecimento da qual o aluno depende, visto que o conhecimento está disponível na Internet. Além disso, muitas vezes, notou-se que os alunos preferem buscar as respostas na Internet, em vez de simplesmente seguir o livro-texto indicado no plano de ensino da disciplina. Logo, ficou claro que o papel do professor deve ser muito mais o de inspirar os alunos a ver sentido em seu curso e desejar aprender, do que apenas o de repassar conhecimentos.

Princípios norteadores: O primeiro princípio norteador foi retirado das Diretrizes Curriculares Nacionais do Curso de Graduação em Engenharia, que apresenta o perfil esperado para o engenheiro, destacado em seu Art 3º: "O Curso de Graduação em Engenharia tem como perfil do formando egresso/profissional o engenheiro, com formação generalista, humanista, crítica e reflexiva, capacitado a absorver e desenvolver novas tecnologias, estimulando a sua atuação crítica e criativa na identificação e resolução de problemas, considerando seus aspectos políticos, econômicos, sociais, ambientais e culturais, com visão ética e humanística, em atendimento às demandas da sociedade." (Conselho Nacional de Educação, 2002).

Com base nessa diretriz, surgiu o entendimento que a disciplina deve focar no desenvolvimento de competências, ao invés da transmissão de conteúdo. Devem ser criadas situações que exijam do aluno posturas crítica, reflexiva, ética e criativa.

O segundo princípio norteador identificado está relacionado com a motivação dos estudantes. Considerou-se uma visão espiritual do ser humano, conforme apresentada por Bahá'u'lláh (1817-1892), o qual afirma que o ser humano é nobre por natureza, e foi criado para levar avante uma civilização em constante evolução (Effendi, 2012). Assim, a forma de motivação deve apresentar metas nobres, enfatizando o papel social do engenheiro e sua capacidade de mudar o mundo, visando atender às demandas da sociedade, em consonância com as diretrizes curriculares nacionais do curso.

Após as etapas de identificação dos fatos e dos princípios norteadores, as seguintes linhas de ação foram definidas: (a) as aulas expositivas devem ser reduzidas, propiciando mais tempo para ações baseadas em PBL; (b) metas nobres devem ser apresentadas aos estudantes, que devem ter a liberdade de escolher os projetos que desejam executar. Propositalmente, os parâmetros iniciais não são definidos, para que o aluno seja responsável por todas as etapas do projeto; (c) os próprios alunos devem identificar demandas da sociedade, formulando o problema e identificando uma solução possível; (d) não deve haver nota para os projetos, para que os alunos possam utilizar a criatividade para testar novas soluções sem o receio de serem penalizados se sua iniciativa não apresentar os resultados esperados. Deve-se criar um ambiente em que os alunos possam discutir suas propostas de solução com o professor; e (e) devem ser propostos também projetos práticos, para que os alunos possam efetivamente implementá-los, como forma de realização pessoal e motivação ao efetivamente construir algo concreto elaborado pelo seu próprio esforço. As etapas de implementação e reflexão são descritas nos capítulos seguintes.

4 Implementação

Com base no que foi identificado e proposto, a disciplina foi completamente reformulada e, neste novo formato, já foi ministrada duas vezes (no segundo semestre de 2016 e no primeiro semestre de 2017). Logo na primeira aula, em vez de apresentar o Plano da Disciplina, algumas questões mais instigantes são colocadas para os alunos: "O que lhe motivou a escolher o curso de Engenharia Elétrica? Qual o seu objetivo?" Esse convite à reflexão parece pegar os alunos de surpresa, haja vista que a maioria está acostumada a não interagir com o professor. Notou-se, nesse momento, que muitos alunos não sabem dizer o porquê de terem escolhido esse curso. Sem ter uma motivação clara, fica mais difícil se interessarem pelos conteúdos.

Em seguida, o Perfil do Engenheiro, conforme consta nas Diretrizes Curriculares (Conselho Nacional de Educação, 2002) é apresentado como um dos objetivos gerais da disciplina. Em consequência dessa abordagem, aprender sobre Máquinas Elétricas coloca-se como consequência direta e evidente, pois é o pano de fundo do desenvolvimento de competências.

Finalmente, uma mensagem de boas-vindas, inspirada em vídeo institucional da Universidade de Brasília (Universidade de Brasília, 2013), é entregue aos alunos, enfatizando bastante que o foco da aprendizagem na disciplina baseia-se em uma postura muito ativa por parte dos estudantes.

4.1 Aulas expositivas

As aulas expositivas foram reduzidas para 50% da carga horária, as quais passaram a abordar os principais aspectos conceituais, visando facilitar o entendimento das máquinas elétricas, com análises e interpretação de resultados matemáticos. Os detalhes disponíveis no livro-texto foram repassados aos alunos como leitura fora do horário de aula. Os 50% restante do tempo foi dedicado às atividades PBL, envolvendo projeto teórico, projeto prático e avaliação.

4.2 Projeto teórico visando atender demandas da sociedade

O primeiro projeto proposto aos estudantes envolve escolher uma demanda da sociedade e apresentar uma solução de engenharia que necessariamente utilize máquina elétrica. Os alunos devem formar duplas, para que possam discutir entre si o projeto. A apresentação deve ser feita para toda a turma em até 10 minutos, com tempo igual para discussão pelos colegas. O único critério exigido é que o projeto seja "tecnicamente razoável", isto é, sem a necessidade de uma análise de viabilidade econômica, permitindo ao aluno utilizar soluções inovadoras e criativas. Exige-se, também, que o aluno justifique a melhor máquina elétrica para a aplicação escolhida, o que lhe força estudar todas as máquinas elétricas para entender a característica de cada uma delas; e que ele dimensione a potência da máquina, o que exige integração com outras disciplinas cursadas, em especial Fenômenos de Transporte.

Como demandas da sociedade, foram apresentados os Objetivos de Desenvolvimento Sustentável (Organização das Nações Unidas, 2015). Tais objetivos se aplicam a diversas áreas do conhecimento, e muitos deles podem ser atingidos utilizando máquinas elétricas. Essa relação entre máquinas elétricas e demandas sociais também causou surpresa aos alunos. Provavelmente, eles achavam que estudariam as equações de motores e geradores, mas não tinham associado que, com esse conhecimento, se tornariam capazes de solucionar problemas e atender a diversas demandas da humanidade. A seguir, apresentam-se algumas importantes demandas relacionadas à disciplina: *Erradicação da pobreza:* motores elétricos alimentados por energia solar podem ser utilizados em comunidades sem acesso à eletricidade para beneficiar produtos e gerar renda; *Fome zero:* motores para bombeamento de água podem melhorar o plantio com irrigação, além de utilizar técnicas que reduzam o consumo de água; *Boa saúde e bem-estar:* geradores de energia podem ser instalados em bicicletas para gerar eletricidade durante o exercício; *Educação de qualidade:* geradores de energia podem iluminar salas de aula em locais sem eletricidade, possibilitando o estudo com luminosidade adequada, além do uso de equipamentos audiovisuais que requeiram eletricidade; *Água limpa e saneamento:* motores podem ser utilizados para que a água de rio passe por filtros, ou bombear esgoto para estações de tratamento; *Energia acessível e limpa e combate às alterações climáticas:* geradores de energia com fontes limpas podem ser projetados; e *Crescimento econômico, inovação, infraestrutura e cidades sustentáveis:* veículos elétricos podem ser projetados para emitir menos gases de efeito estufa e facilitar o transporte de pessoas e de cargas.

Visando melhor orientar os estudantes sobre como abordar esse complexo projeto de engenharia, foi solicitada na disciplina as seguintes atividades parciais:

- Apresentação de um seminário sobre uma máquina elétrica real, onde os alunos devem pesquisar uma aplicação parecida com o projeto escolhido. Ao estudarem, por conta própria, um problema já resolvido, terão uma base inicial para propor uma solução. Foram disponibilizadas revistas técnicas especializadas em aplicações elétricas de transporte, robótica e energia, para servir como ponto de partida. Os seminários tem duração de 10 minutos e são apresentados para toda a turma que, nos 10 minutos seguintes, pode discutir a aplicação e identificar as principais características da máquina elétrica selecionada. Nessa etapa o professor complementa o seminário, chamando atenção para os principais pontos e apresentando exemplos de como essa aplicação pode ser extrapolada para atender outras demandas; e
- Apresentação de um esboço da solução, onde os alunos, em duplas, devem apresentar uma primeira proposta de atendimento à demanda escolhida. Não há formato padrão ou número mínimo de páginas para o esboço, visando deixar a criatividade e inovação livres. O professor, então, lê e comenta, como um *feedback* ao aluno, visando identificar pontos que podem ser melhorados ou até dúvidas conceituais que devem ser sanadas. Os comentários do professor são colocados na forma de perguntas, para estimular a reflexão sobre os pontos mais importantes do projeto. Tal etapa é importante pois os estudantes ainda tem tempo de repensar a solução, caso alguma dúvida conceitual os tenham feito escolher uma máquina elétrica inadequada.

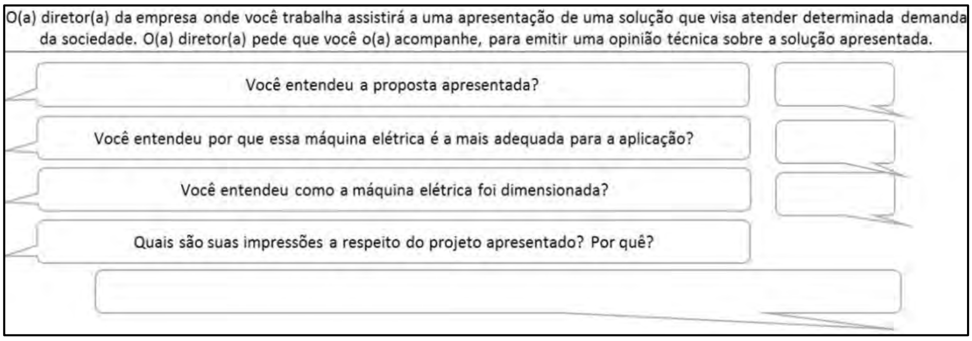
4.3 Projeto prático: construção artesanal de veículo elétrico

Solicita-se também um segundo projeto, que consiste na construção artesanal de um veículo elétrico (tipo carrinho de brinquedo) que deve ser feito com pilhas e fios de cobre. Os alunos, também em duplas, são livres para criar a solução que desejarem. Tal atividade exige um profundo conhecimento de como os campos magnéticos interagem para gerar conjugado no motor elétrico, logo é necessário que eles efetivamente entendam o conteúdo para projetar um veículo elétrico que funcione. As dificuldades inerentes à construção de um protótipo estimulam a capacidade de análise dos alunos para sanar problemas práticos.

4.4 Avaliação

A ideia é que o aluno possa refletir sobre sua real absorção do conteúdo quando ele é convidado a opinar a respeito. Durante a apresentação final dos projetos, todos os alunos da turma também têm papel ativo, pois são estimulados a opinar tecnicamente sobre a solução. Trata-se de uma forma de autoavaliação pois, se o aluno não conseguir entender a apresentação dos colegas, precisa rever suas bases teóricas. É criada uma situação hipotética de atuação como engenheiro, onde deve-se responder o formulário apresentado na Figura 1. No final, os formulários são entregues à dupla que apresentou o projeto; ao invés de nota, eles recebem o *feedback* dos próprios colegas.

Figura 1. Formulário que os alunos devem preencher enquanto assistem às apresentações dos colegas


O(a) diretor(a) da empresa onde você trabalha assistirá a uma apresentação de uma solução que visa atender determinada demanda da sociedade. O(a) diretor(a) pede que você o(a) acompanhe, para emitir uma opinião técnica sobre a solução apresentada.

Você entendeu a proposta apresentada?

Você entendeu por que essa máquina elétrica é a mais adequada para a aplicação?

Você entendeu como a máquina elétrica foi dimensionada?

Quais são suas impressões a respeito do projeto apresentado? Por quê?

Além disso, foram propostas duas avaliações escritas. Foi enfatizado que o objetivo da avaliação não é mostrar ao professor que o aluno sabe resolver o exercício (que, muitas vezes, tira nota alta apenas decorando fórmulas), mas a ideia é que o aluno verifique se ele realmente compreendeu os principais conceitos. A primeira avaliação possuía diversas questões complexas, abordando os pontos mais importantes da disciplina, que deveria ser respondida em sala de aula, porém com possibilidade de consulta tanto a materiais quanto aos próprios colegas. Logo, se o aluno identificar que possui dúvida sobre as questões apresentadas, tem a oportunidade de discuti-las com os colegas, visando melhorar seu entendimento. A segunda avaliação, realizada na última aula, consiste em uma autoavaliação, onde o aluno declara, de forma justificada, a nota que considera justo receber na disciplina, com base em seu desempenho e no entendimento do conteúdo apresentado. As seguintes questões foram apresentadas na autoavaliação: (a) elabore um texto descrevendo o quanto você conseguiu aprofundar seus conhecimentos sobre máquinas elétricas. Se desejar, descreva como a pesquisa para o seminário, a elaboração do projeto documental, a redação de comentários sobre as apresentações de máquinas elétricas em aplicações práticas, a construção do veículo elétrico, a resolução de exercícios, o estudo de provas passadas, os artigos técnicos disponíveis no Moodle e as aulas teóricas contribuíram para facilitar seu entendimento sobre o assunto da disciplina; e (b) faça uma autoavaliação sincera sobre sua dedicação à disciplina e seu aprendizado sobre máquinas elétricas. Qual nota você acha justo receber?

No momento da autoavaliação é enfatizada a importância da conduta ética do aluno, o qual deve lançar a nota justa. É confirmada a confiança do professor no aluno, de que a nota que o aluno informar será a nota final da disciplina.

5 Resultados e Reflexão

As técnicas utilizadas podem ser resumidas da seguinte forma: (a) passivas: aulas expositivas; informações no Moodle (artigos de revistas e exercícios); e (b) ativas: pesquisar (seminário); projetar (projeto documental visando atender demandas da sociedade); analisar máquinas elétricas para aplicações práticas (comentários sobre os seminários e projetos); construir (veículo elétrico); e resolver (exercícios e provas passadas).

Essas técnicas foram aplicadas a duas turmas de alunos de Máquinas Elétricas, sendo que 64 alunos cursaram no segundo semestre de 2016 e 62 alunos cursaram no primeiro semestre de 2017. Logo, os resultados são baseados em uma amostra de 126 estudantes. Os resultados apresentados a seguir foram coletados dos textos dissertativos que foram escritos na autoavaliação.

As técnicas utilizadas foram aprovadas por 99% dos alunos, os quais declararam que aprenderam mais nesse formato do que com aulas expositivas convencionais. Somente 1 aluno declarou que preferia o método convencional de ensino, mas sem apresentar justificativa. Alguns alunos relataram que várias disciplinas costumam avaliar sua capacidade de decorar fórmulas; outros disseram que, em várias disciplinas, aprenderam a resolver exercícios mas não a solucionar problemas; ainda outros disseram que ia muito bem em provas, mas a elaboração de um projeto, onde não há um enunciado pronto com todos os dados necessários, os tirou de sua zona de conforto e os forçou a ter uma visão mais completa dos problemas de engenharia, e que essa abordagem orientada a projetos os motivou a aprender mais sobre máquinas elétricas.

A apresentação de metas nobres, e a confiança transmitida pelo professor de que os alunos são capazes de realizar grandes feitos com o conhecimento adquirido no curso, também demonstrou resultado positivo, pois os alunos puderam abordar diversas áreas de aplicação, de acordo com seu interesse. Por exemplo, um aluno interessado em engenharia biomédica fez o projeto de próteses robóticas, outro interessado em telecomunicações projetou um *drone* para medir a qualidade do sinal de celular em determinada área, e assim por diante. Vários relataram que a possibilidade de aplicação social da engenharia foi um grande motivador.

A prova com consulta, inclusive aos colegas, apresentou resultados positivos. Diversos alunos relataram que consideraram o método efetivo, pois tiveram a chance de sanar as dúvidas quando essas apareceram, por meio de um caloroso debate com os colegas. Entretanto, muitos afirmaram que não haviam se preparado para a avaliação, não estudando o livro-texto previamente. Alguns alunos sugeriram que as atividades para casa deveriam ser de entrega obrigatória, para estimular o aluno a fazê-la.

O projeto prático de construção do veículo elétrico teve resultados limitados. 90% dos alunos relataram que tentaram criar seu próprio veículo mas, devido à complexidade do projeto, optaram por copiar um modelo mais simples disponível na internet. Ficou clara que há uma grande preocupação dos alunos em ter um projeto que funcione, ao invés de apreciarem o conhecimento adquirido no processo, onde as dificuldades suscitam reflexões. Dos projetos mais criativos, elaborados por 10% dos alunos, apenas 2 funcionaram; esses alunos que ousaram fazer diferente, mesmo sem funcionar, apresentaram suas ideias para a turma, o que gerou uma rica reflexão de que existem várias soluções para um mesmo problema.

A autoavaliação também teve resultados limitados. Essa etapa visava exigir uma postura ética por parte dos alunos, de realmente analisarem o quanto aprenderam, e lançarem a nota justa. A Tabela 1 apresenta as notas resultantes da autoavaliação. Foram identificadas as seguintes situações: (a) grande parte dos alunos, por simplesmente realizarem todas as atividades solicitadas (avaliações, seminário, projeto e construção de veículo elétrico) lançaram notas entre 9 e 10, pois entenderam que cumpriram todos os requisitos colocados pelo professor, logo merecem notas elevadas; (b) os alunos que, de forma acertada e dentro do proposto na disciplina, ousaram inovar na construção do veículo elétrico, mas o mesmo não funcionou, lançaram notas entre 7 e 8,9; e (c) alguns alunos (3% da amostra) demonstraram imaturidade e lançaram nota 10 simplesmente pelo poder recebido de definir sua nota, e não pela análise sincera e consciente de seu desempenho.

Uma consequência da autoavaliação foi a ausência de reprovação. Entende-se, entretanto, que o aluno, ao elaborar um seminário, formatar um projeto, construir um veículo elétrico e resolver exercícios, adquiriu pelo menos o mínimo necessário para ter aprovação, visto que as atividades propostas foram colocadas como obrigatórias para aprovação na disciplina.

Tabela 1 – Notas declaradas pelos alunos na autoavaliação.

Nota	Turma 2016/2	Turma 2017/1
9 – 10	38	41
7 – 8,9	19	17
5 – 6,9	7	4
Menor que 5	0	0
Total de alunos autoavaliados	64	62

6 Conclusões

A aplicação de técnicas ativas de aprendizagem na disciplina "Máquinas Elétricas" do curso de Graduação em Engenharia Elétrica da Universidade de Brasília foi testada por dois semestres consecutivos, abrangendo uma amostra de 126 estudantes, e teve 99% de aceitação por parte dos alunos. Os pontos principais que melhoraram a motivação dos alunos e os estimularam a estudar o conteúdo de forma ativa foram: a abordagem de projetos com ênfase em metas nobres, em que os estudantes atendem demandas da sociedade, fornecendo senso de propósito, e o ambiente livre de notas, onde o aluno pôde apresentar suas ideias e seus projetos sem o receio de ser negativamente avaliado se estiver errado, fornecendo solo fértil para criatividade e soluções inovadoras. Diversos pontos ainda precisam ser melhorados, tais como o estímulo à resolução de exercícios fora do horário de aula, que poderão ser implementados utilizando ferramentas modernas do tipo Moodle, por exemplo.

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Background Factors in the Choice of the Production Engineering Course with Active Methodology: A Study through Structural Equations

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Abstract

This study aims to present a validated model of the antecedent factors that influence the student in the decision for the graduate course in Production Engineering with active methodology PBL (Problem Based Learning). The understanding of such variables and their relationship with active methodologies allows the identification of the profile of undergraduate students and avoid avoidance and dropout, which are phenomena of great negative impact on the university and the student. The decision criteria were grouped according to an adaptation of Bomtempo et al. (2012) and Santos (2016), totalling four constructs: social factors, psychological factors, economic factors and intention to pursue a career in the area. The study model was tested through a quantitative research instrument with 152 students of the Production Engineering course at the University of Brasília - Brazil. The sample was of probabilistic type and with statistical power of 80%. The questionnaire was validated with composite reliability (fc = 0.84). The collected data were analysed using the structural equation techniques through the SmartPLS program and later by evaluation of trends of results by a professional in education. The research was exploratory with a qualitative-quantitative approach. The results show that the prediction of choosing a Production Engineering course with active methodology is explained by the economic, social and psychological factors in 22.7%, and validate the hypotheses that the economic factor (12.9%) and psychological factor (7, 9%) has a strong influence on the intention for this graduation.

Keywords: Active Methodologies, Problem Based Learning, Production Engineering, Structural Equations

Fatores Antecedentes na Escolha do Curso de Engenharia de Produção com Metodologia Ativa: Um Estudo por Meio das Equações Estruturais

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Resumo

Este estudo tem como objetivo apresentar um modelo validado dos fatores antecedentes que influenciam o aluno na decisão pelo curso de graduação em Engenharia de Produção com metodologia ativa PBL (Problem Based Learning). O entendimento de tais variáveis e suas relações com as metodologias ativas, possibilitam a identificação do perfil dos estudantes de graduação e a partir dele evitar evasões e abandonos, que são fenômenos de grande impacto negativo para universidade e para o aluno. Os critérios de decisão foram agrupados segundo uma adaptação dos modelos de Bomtempo et al. (2012) e de Santos (2016), totalizando quatro construtos: fatores sociais, fatores psicológicos, fatores econômicos e intenção em seguir carreira na área. O modelo do estudo foi testado através de um instrumento de pesquisa quantitativa com 152 alunos do curso de Engenharia de Produção da Universidade de Brasília- Brasil. A amostra foi do tipo probabilística e com poder estatístico de 80%. O questionário foi validado com confiabilidade composta (fc=0,84). Os dados coletados passaram por análises utilizando as técnicas de equações estruturais por meio do programa SmartPLS e posteriormente por avalição de tendências de resultados por uma profissional da área da educação. A pesquisa foi de cunho exploratório com abordagem quali-quantitativa. Os resultados apresentam que a predição por escolher um curso de Engenharia de Produção com metodologia ativa é explicada pelos fatores econômicos, sociais e psicológicos em 22,7%, e validam as hipóteses que o fator econômico (12,9%) e psicológico (7,9%) tem forte influência na intenção por essa graduação.

Palavras-Chave: Metodologias Ativas, *Problem Based Learning*, Engenharia de Produção, Equações Estruturais

1 Introdução

Apesar do crescimento do curso de Engenharia de Produção no Brasil, o ensino superior brasileiro é marcado pelo número excessivo de vagas e o abandono dos cursos de graduação por seus alunos (Pereira, 2003). Segundo dados da Confederação Nacional da Indústria (CNI) de 2015, a elevada taxa de evasão no Brasil se repete ao observar os cursos de Engenharia, os índices alcançados por essa graduação são bem maiores do que os índices de cursos tradicionais como Direito e de Medicina. A Evasão anual do curso de Medicina, no período de 2011 e 2012, foi de apenas 1,50%, enquanto o curso Direito 12%, já os cursos de Engenharia apresentaram índices de 16%. Tais números são preocupantes, visto que menos de 50% dos ingressantes em Engenharia concluem a graduação (CNI, 2015).

Escrivão Filho & Ribeiro (2009), explicam que nos cursos de Engenharia, ainda predominam os currículos tradicionais, a fraca interdisciplinaridade e uma integração tardia dos componentes curriculares entre a teoria e a prática e o mundo acadêmico e profissional (Escrivão Filho & Ribeiro, 2009). Neste contexto, a Universidade de Brasília adotou em 2011, em seu curso de Engenharia de Produção (EPR) a metodologia ativa PBL (*Project Based Learning*-Aprendizagem baseada em projetos). Segundo Mariano, *et al* (2017), o Projeto Pedagógico do Curso de Engenharia de Produção da Universidade de Brasília-UnB, levou em consideração a estrutura da cidade de Brasília, com um amplo mercado de trabalho em serviços, adotando uma perspectiva de serviços via uso de projetos tradicionais como PMBOK (Gerenciamento de Projetos de Conhecimento), métodos ágeis e premissas de sustentabilidade. Desde então, a EPR, têm crescido durantes os anos, ganhando a segunda colocação de melhor curso de Engenharia de produção do Brasil, impactando diretamente no crescimento do número de alunos. Deste modo, determinar quais fatores tem maior influência sobre a escolha do curso de Graduação de Engenharia de Produção da Universidade de Brasília, é importante para saber o impacto do curso via metodologias ativas na decisão por sua graduação. Devido à complexidade da escolha do curso de graduação e visto que não existem muitos estudos voltados para o caso particular da escolha de um curso de Engenharia de Produção com metodologia ativa, definiu-se a seguinte questão para orientar o estudo: Quais os fatores influenciam na decisão pelo curso de graduação em Engenharia de Produção com metodologia ativa da Universidade de Brasília?

A pesquisa justifica-se socialmente, pois a identificação dos motivos que afetam a decisão dos estudantes pelo curso de Engenharia de Produção com metodologia ativa, contribuem para a definição de um perfil dos ingressantes desse curso de graduação, pois indicam os principais fatores de tal escolha. Dessa forma, os cursos de Engenharia de Produção tornam-se mais adaptados aos alunos, aumentando sua satisfação com a escolha vocacional e consequentemente diminuindo o número de abandonos. Sendo assim, a pesquisa desenvolvida justifica-se na área da Engenharia da Produção.

Assim, o objetivo desta pesquisa é apresentar um modelo validado dos fatores antecedentes que influenciam o aluno na decisão pelo curso de graduação em Engenharia de Produção com metodologia ativa PBL (*Problem Based Learning*) via projetos.

Para alcançar o objetivo desta pesquisa foi realizada uma pesquisa exploratória por meio das equações estruturais.

2 Fundamentação teórica

2.1 Fatores que influenciam na escolha do curso de graduação

Segundo Almeida & Pinho (2008), a escolha da profissão é uma das decisões mais importantes na vida de um jovem. Essa dificuldade advém dos diversos critérios que rodeiam essa escolha e a influenciam. Alguns desses fatores são enumerados nos estudos de Santos (2005) e Lent *et al.* (2000), dentre eles: situação econômica, religião, valores, crenças, situação econômica e política do pais, características pessoais, família, dentre outros.

Devido aos inúmeros fatores que influenciam a escolha da graduação é interessante analisa-los de uma forma macro, ou seja, agrupando-os em grandes grupos, para facilitar a análise de seus níveis de influência, como em um grande número de estudos da área (Soares, 1987; Peleias & Nunes, 2015; Bomtempo, 2005; Bomtempo *et al.*, 2012; Hey *et al.* 2015; Santos, 2016; Lent, 1994). Todavia, para esse estudo será utilizado o modelo de Bomtempo et al. (2012), que teve como base a teoria de Crites (1974), e com algumas adaptações do modelo de Santos (2016).

A classificação de Crites (1974) divide as teses vocacionais segundo sua natureza, sendo elas psicológicas, econômicas, sociais e gerais. Tendo em vista que as teorias gerais buscam adaptar aspectos individuais e ambientais, pode-se considerar que as teorias centrais são psicológicas, sociais e econômicas (Bomtempo *et al.*, 2012). Bomtempo *et al.* (2012) desenvolveu um modelo de estudo, baseado na teoria de Crites (1974), com 3 variáveis principais: fatores sociais, fatores econômicos e fatores psicológicos. Para esse estudo utilizou-se uma adaptação dos modelos de Bomtempo et al. (2012) e de Santos (2016), totalizando 4 variáveis: fatores sociais, fatores econômicos, fatores psicológicos e intenção.

2.2.1 Fatores Sociais

Os Fatores Sociais representam aspectos presentes no meio em que o indivíduo está inserido e tem influência em suas decisões, não sendo exclusivos para a decisão profissional. Tais fatores são reflexos da cultura, classe social, religião, família, região demográfica, dentre outros fatores presente no contexto do aluno. O adolescente encontra-se em uma fase de sua vida de transição, onde ele passa a ter controle e independência entre o seu mundo e o mundo o qual o rodeia, dessa forma, durante essa coexistência entre as duas experiências ele ainda sofre fortes influências do meio em sua formação (Moreno, 1978), e consequentemente em sua tomada de decisão.

A interação com o contexto material e social o em que o indivíduo vive, faz com que ele desenvolva interesse, valores, crenças, habilidades, conhecimento, dentre outras características, que compõem o aprendizado social, que tem grande potencial de influência na decisão pelo curso de formação (Moura & Menezes, 2004). O ambiente social pode também alterar e até mesmo restringir as opções de escolha profissional, tendo em vista os pontos abordados por Bomtempo (2005), que enfatiza que as estruturas sociais de um ambiente podem alterar os moldes e as referências de um cargo profissional. Tal ponto defendido por Bomtempo et al. (2012) é reafirmado no estudo de Correll (2001), ao discorrer que fatores sociais, tais como crenças culturais, podem alterar a percepção do indivíduo com relação a uma profissão e até mesmo suas decisões ocupacionais.

A família é um dos fatores determinantes na tomada de decisão do jovem, uma vez que a mesma possui seu próprio contexto social, sua história, suas características, crenças e aspirações. Segundo Bandura (2001), as influencias socioeconômicas, familiares e autorreferentes apresentaram um efeito indireto com relação a escolha profissional do aluno. Posto isso, o jovem na eminência de sua escolha profissional deve considerar não somente fatores inerentes a ele próprio, mas também deve escolher como proceder com as informações referentes a sua família.

Os fatores sociais são inerentes a cultura e a sociedade, ou seja, rodeiam o aluno em seus diversos contextos sociais. As interações que o homem tem com o ambiente a sua volta, pessoas, culturas, religiões, família, dentre outros, proporciona a ele diversas informações, que mais tarde vão se tornar conhecimento e consequentemente moldam valores e comportamentos (Lent *et al.,*1994). Posto isso, desenvolveu-se a hipótese:

H1: Os fatores sociais influenciam na intenção de cursar a carreira de Engenharia de Produção com Metodologia Ativa.

2.2.2 Fatores Psicológicos

Fatores Psicológicos pressupõem o livre arbítrio, a liberdade de opção. Esses fatores são características intrínsecas ao sujeito, suas crenças, gostos, habilidades, aspirações, entre outras, que são desenvolvidas e moldadas com o passar do tempo. De acordo com Bland (1995), as características individuais do aluno interferem na construção de seus valores, sendo os últimos direcionadores de seus desejos profissionais. Essas particularidades permitem a identificação do indivíduo com as características atribuídas as profissões almejadas, fazendo com que ele desenvolva afinidades e tome sua decisão.

Ao escolher a sua graduação, o indivíduo não somente escolhe uma profissão, ele escolhe o meio pelo qual pretende atualizar-se (Super & Bohn Jr., 1980).

Já Holland (1975) *apud* Bomtempo *et al.* (2012), apresentam uma concepção similar à de Super (1980) quando enuncia que o ser humano busca vocações e meios congruentes com suas características pessoais, onde possam usufruir de suas habilidades e se expressar naturalmente. A teoria de Holland afirma que através de nossas heranças e experiências sociais e culturais em um meio, é possível determinar seis tipos de personalidades, onde cada uma tem uma predisposição natural para cada área profissional. Assim, segundo a afirmação de estudos da área (Hauer, 2008; Hey *et al.,* 2015; Panucci-Filho, 2013), sobre a influência dos fatores econômicos na escolha da carreira, e considerando os contrapontos apresentados por Bomtempo (2005), formulou-se a seguinte hipótese:

H2 : Os fatores econômicos influenciam na intenção de cursar a carreira de Engenharia de Produção com Metodologia Ativa.

2.2.3 Fatores Econômicos

Os Fatores Econômicos da escolha profissional estão relacionados a aspectos de natureza financeira-econômica, onde o aluno tende a analisar fatores como remuneração e estabilidade e também relacionada a imagem financeira da profissão, como o prestígio e status. Ao escolher a carreira profissional, os alunos tendem a privilegiar questões relacionadas ao estilo de vida oferecido (Hauer, 2008). Hey et al. (2015), explica tal comportamento ao indicar que o aluno tende a considerar esses pontos com uma perspectiva de recompensa pelos esforços incorridos nos estudos, visando a vaga almejada.

Sobre outra ótica, é possível inferir que os fatores financeiros podem ser definidos pela compatibilidade financeira do aluno e dos encargos e remunerações de cada profissão, uma vez que devido a dificuldades financeiros, existem jovens que não conseguem arcar com as despesas necessárias para certos cursos de graduação (Panucci-Filho, 2013).

Assim, o fator psicológico é um critério importante na decisão profissional, conforme os estudos de Bland (1995), Super & Bohn Jr. (1980) e complemento apresentado no estudo de Holland (1975) *apud Bomtempo et al.* (2012). Tendo essas ideias em vista e suas relações, apresentadas no referencial teórico, definiu-se a seguinte hipótese:

H3: Os fatores psicológicos influenciam na intenção de cursar a carreira de Engenharia de Produção com Metodologia Ativa.

2.2.4 Intenção

Segundo Ramírez *et al*. (2015), a intenção de uso é o grau em que uma pessoa formulou planos conscientes para atingir determinado fim, neste caso: cursar a carreira de engenharia de produção.

Para Dias (1995), intenção é o objetivo que leva o indivíduo a ter certos comportamentos. A intenção é, portanto, a vontade de alcançar algum objetivo, que por consequência desencadeia comportamentos congruentes. Quanto maior a subjetividade dos comportamentos e a percepção do domínio dos mesmos, maior a vontade de realizar o comportamento associado à sua intenção (Ajzen & Fishbein, 2000).

3 Métodos

Para o desenvolvimento desse trabalho de pesquisa foi escolhido o método exploratório, com abordagem quantitativa. A técnica escolhida para o estudo foi a análise multivariada, que permite explicar com grande riqueza de informações modelo com poucos componentes, visto que essa técnica possibilita que a multidimensionalidade do modelo seja agrupada de forma coerente (De Andrade Tolentino *et al*., 2016)

O local de pesquisa foi a Universidade de Brasília (UnB), localizada no Distrito Federal, Brasil. O instrumento de pesquisa utilizado para coleta foi o questionário, que usou perguntas adaptadas de Bomtempo et al. (2012), que teve como base a teoria de Crites (1974), relacionadas aos construtos: fator social, fator econômico, fator psicológico, enquanto as perguntas relacionadas ao construto da intenção de cursar Engenharia de Produção, foram adaptadas de Santos (2016). Após a união das duas adaptações realizadas, o instrumento de coleta totalizou 39 questões, a primeira tinha como objetivo selecionar os participantes conforme os critérios de inclusão e exclusão, contendo apenas duas opções, sim ou não. As outras 38 perguntas utilizaram a escala *Likert* de cinco pontos, sendo as opções as seguintes: discordo completamente, discordo, neutro, concordo e concordo completamente. A pesquisa foi dividida em 4 temas, sendo esses relacionados aos 4 construtos pré-definidos. O construto fatores psicológicos possuía 14 questões, fatores sociais e fatores econômicos 10 questões e intenção 4 questões. A teoria oferece constructos, que por meio de questionários são testados e validados, obtendo assim os resultados de maior relevância para a amostra estudada.

O questionário foi preenchido pelos participantes via plataforma online de questionários do *Google Forms*, e sua divulgação foi realizada via rede social. Para definir a amostra foi utilizado o método probabilístico. O questionário estava disponível no período de 13/03/2017 até 23/04/2017. As amostras para PLS-SEM se baseiam em propriedades de regressão OLS (Hair, *et al.* 2017). A amostra foi calculada por meio do *software G*Power*. O efeito da força foi médio (0,15), ideal para estudos exploratórios, a significância foi de 5% e nível de poder estatístico foi 0.8, como o modelo possui 3 variáveis independentes, a amostra mínima necessária foi de 77 respondentes. No total, foram obtidas 157 respostas, dentre as quais 5 foram excluídas pois os respondentes não pertenciam ao curso de Engenharia de Produção da UnB, totalizando 152 indivíduos da amostra final.

Os resultados da pesquisa foram colocados em uma planilha do Excel, com o objetivo de organizar a estrutura dos dados para posterirormente serem lançados no programa *SmartPLS*. O programa *SmartPLS* utiliza a Regressão de Mínimos Quadrados Parciais, é utilizado para analisar dados de pesquisa e testar hipóteses de relação entre as variáveis. Segundo Falk e Miller (1992), a análise de mínimos quadrados visa que as variáveis independentes, se tornem excelentes em prever a variável dependente. O PLS pode ser aplicado em diversos tipos de pesquisa, a seguir estão alguns dos critérios, baseados na teoria de Chin (1998), que podem indicar seu uso: quando as relações entre os construtos são teóricas e suas manifestações não são amplamente conhecidas, a relações entre as variáveis latentes são conjecturais, as variáveis encontram-se em diferentes níveis de medição, existe um certo grau de não confiabilidade com relação as variáveis diretamente observáveis, se o modelo em questão apreendo número elevado de variáveis latentes e manifestas.

4 Resultados e Análises

Inicialmente foram realizados testes de confiabilidade (confiabilidade de item e composta) e validade (variância média extraída e validez discriminante) do modelo e instrumento. Todos os testes foram confirmatórios com confiabilidade composta de (*fc*=0,84).

4.1 Mensuração do Modelo Estrutural

Posterior as análises de confiabilidade e validade do modelo passa por estudos de sua valoração e comprovação de hipóteses. Para determinar os resultados de predição e a influência das variáveis independentes sobre as dependentes, utilizou-se os coeficientes R^2 e β.

O coeficiente R^2 indica o quanto as variáveis independentes explicam o a variável dependente, indicando o poder de predição do modelo (Cepeda & Roldán, 2004). A segunda análise está relacionada ao coeficiente de *patch β*, que mede em que grau uma variável independente explica a variável dependente. Estipulou-se como satisfatórios coeficientes com valores acima de 0,2, conforme Ramirez, Mariano e Salazar (2014).

Pode-se observar na figura 1 o modelo calculado:

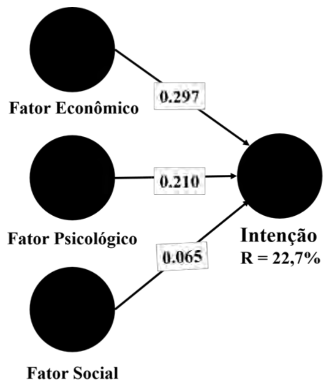

Figura 1. Modelo de Equações Estruturais

Fonte: Elaborado pelo autor com base nos resultados do *SmartPLS*

Pode-se observar que no modelo de estudo (figura 1), as variáveis fator econômico, fator social e fator psicológico explicam em 22,7% a intenção em seguir carreira na área de Engenharia de Produção, conforme o valor apresentado na Figura 10. Uma predição é considerada satisfatória quando atinge valores de R^2 acima de 0,1, quando ultrapassa o valor de 0,2 é considerada reveladora (Falk & Miller, 1992).

Analisando os Betas na Figura 1, observa-se que o fator econômico influencia em 0,29 graus, equivalente a 12,9%, na intenção de estudar Engenharia de Produção com metodologia ativa, apresentando uma forte relação entre as variáveis. O fator psicológico também apresentou um valor de coeficiente satisfatório, demonstrando que o mesmo influencia a decisão de cursar Engenharia de Produção com metodologia ativa na área em 0,21 graus, ou 7,9%. Por fim, o fator social foi o único teve o valor do coeficiente β abaixo de 0,2, sendo seu resultado de 0,065, similar a 1,9%, o que permite concluir que a relação entre as variáveis é sem significância. Devido aos valores próximos de 0,2 apresentados pelas hipóteses H2 e H3 e visando complementar a análise do coeficiente de *patch β,* utilizou-se a análise *Bootstrapping*. Segundo Chin (1998), esta análise possibilita mensurar a solidez das estimações do PLS. Tal análise utiliza-se do teste *t student*, onde para que a hipótese seja aceita o valor deve ser superior a 1,96 e do *P value*, a qual aceita hipóteses com valores inferiores a 0,05 (Ramirez *et al.*, 2014).

Tabela 1- Teste de Hipóteses

	Hipótese	Beta (β)	%	*t de student*	*p-value*	Resultado
H1	Fator Social -> Intenção	0.065	1.9%	0.593	0.553	Rejeitada
H2	Fator Econômico -> Intenção	0.297	12.9%	2.727	0.007	Aceita
H3	Fator Psicológico -> Intenção	0.210	7.9%	2.993	0.003	Aceita

Fonte: própria

Os resultados destes testes permitem ratificar a valoração do modelo e suas hipóteses por meio de testes mais reconhecidos na literatura como *t de student* e *p-value*. Conforme a Figura 11 e a Tabela 11, nota-se que elas corroboram com os resultados encontrados com o coeficiente β, afirmando novamente as fortes relações entre o fator econômico e a intenção, com valor de *t de student de* 2,727 e *p-value* de 0,007, e do fator psicológico com a intenção, com valor de *t de student* de 2,993 e *p-value* de 0,003, e confirma a baixa significância da relação entre o fator social e a intenção de cursar Engenharia de Produção com metodologia ativa, com valor de *t de student* de 0,593 e *p-value* de 0,553.

Os resultados apresentados na Tabela 1 demonstram que a intenção de cursar Engenharia de Produção com metodologia ativa é fortemente influenciada pelo fator econômico, ou seja, por relações de custo benefício, remuneração e identificação com os padrões econômicos de profissionais da área. Esse resultado comprova a hipótese H2 do estudo e vai de encontro com as ideias de Hauer (2008). É possível inferir que a intenção em cursar engenharia de produção com metodologia ativa é explicada em grande parte pelo fator psicológico, demonstrando que a escolha é relacionada ao desenvolvimento pessoal e intelectual, esperada pelos alunos. Os dados apresentados corroboram com o estudo de Holland (1975) *apud* Bomtempo et al. (2012) e confirmando a hipótese H3. Por outro lado, a relação entre intenção e fatores sociais demostrou-se fraca, mostrando que o prestígio da carreira e sua colocação no mercado não tem tanta importância na escolha pela graduação com metodologia ativa. Tais ideias são contrárias as de Moura & Menezes (2004), Chanlat (1995) & Correll (2001). Talvez o fato de Engenharia da Produção ser uma carreira nova e a confusão existente por parte do mercado sobre sua real atuação possa dar a impressão ao aluno de uma carreira ainda sem identidade. Um outro fator pode ter sido a amostra, onde os semestres iniciais possuem maior número de alunos e logo maior quantidade de respondentes deste estudo, sendo assim, estes discentes ainda não possuem uma visão das possibilidades do curso.

De modo geral os resultados encontrados suportam em parte as teorias vocacionas de Crites (1974), pois aceitam as influencias dos fatores econômicos e psicológicos nas decisões vocacionais, porém negam o impacto social nessa questão. Acredita-se que a exclusão do fator social como relevante para predição da intenção em seguir carreira na área de Engenharia de Produção, deve-se a maioria dos respondentes da pesquisa serem jovens e ainda encontrarem-se nos primeiros semestre da graduação, o que pode indicar pouco conhecimento sobre o mercado o qual a Engenharia de Produção está inserido e suas interações sociais.

5 Considerações finais, limitações e futuras linhas de pesquisa

Os resultados apresentados nesse trabalho contribuem para desvendar o perfil dos alunos do curso de Engenharia de Produção e direcionar ações institucionais das universidades. Uma vez conhecidos os fatores que influenciam na escolha do curso em questão, a identificação de potenciais candidatos a ingressar no curso de graduação é facilitada e possibilita a IES tomar decisões que atendam as expectativas e necessidades dos ingressantes.

Visto que os fatores econômicos apresentaram influência significante na intenção em seguir carreira em Engenharia de Produção, reforça a ideia de que os esforços das IES para atrair os candidatos com o perfil do curso devem ser voltados para o custo benefício da graduação. Ao se tratar de uma instituição pública, isto pode-se traduzir na comparação entre os esforços despendidos durante toda formação, sendo eles tempo de estudo, dificuldade das matérias, dinheiro com materiais, com a remuneração e padrões financeiros proporcionados por cargos ocupados por esse tipo de profissional em um futuro.

Outro fator que apresentou grande significância na escolha da graduação em Engenharia de Produção com metodologia ativa, foi o fator psicológico. Tendo em vista seus indicadores, é possível sugerir que para uma divulgação clara e objetiva do curso e para criar maior identificação entre o aluno e a graduação escolhida, é preciso destacar de forma clara as habilidades e conhecimentos adquiridos e desenvolvidos durante sua formação. Em posse dessas informações, o aluno percebe se as características elencadas condizem com o desenvolvimento pessoal e profissional almejado por ele possibilitando uma escolha profissional mais eficiente.

Devido a fraca relação entre a intenção e os fatores sociais, percebe-se que as informações relacionadas ao prestígio da carreira e sua colocação no mercado, não tem tanta importância para os ingressantes da graduação. Portanto, tais dados não devem ser o foco das IES para fundamentar suas ações e tão pouco o foco de alunos que tem o interesse em ingressar na área. Porém, esse fator não deve ser deixado totalmente de lado, pois sua baixa significância pode ser explicada pelo pouco conhecimento de mercado dos participantes da pesquisa e pelo curso de Engenharia de Produção ser considerado novo se comparado com cursos mais tradicionais como Direito, Medicina e Engenharia Civil.

Assim, o problema de pesquisa do estudo foi “Quais os fatores influenciam na decisão pelo curso de graduação em Engenharia de Produção com metodologia ativa da Universidade de Brasília? ”, foi respondido por meio dos fatores econômicos e psicológicos. A valoração do modelo, com valor de 22,7%, demonstra que o mesmo consegue explicar a intenção de cursar Engenharia de Produção com metodologia ativa de maneira significativa e reveladora.

Dessa forma, o objetivo geral do estudo, que era apresentar um modelo validado dos fatores antecedentes que influenciam o aluno na decisão pelo curso de graduação em Engenharia de Produção, foi alcançado.

Algumas limitações deste trabalho podem ser citadas. Dentre elas a limitação de aplicação do instrumento, devido à dificuldade de participação. Outra limitação que pode ser citada falta de modelos na literatura relacionados ao curso de Engenharia de Produção, limitando a perspectiva de explorar mais modelos.

Em futuros estudos relacionados ao tema, sugere-se o estudo de outras variáveis que influenciam na decisão pela graduação em Engenharia de Produção, complementando este estudo. Outro ponto interessante para posteriores pesquisas, seria tornar o objeto de pesquisa mais abrangente, envolvendo um maior número de alunos de diferentes instituições.

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Results of the Active Methodology in Entrepreneurial Behavior: a Study conducted with Control Group

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Abstract

The general objective of this study was to identify how the use of the active learning methodology influences the entrepreneurial behavior. To achieve this goal, a comparison was made between a course that uses an active methodology through Problem Based Learning (PBL) and another that uses a non-active teaching methodology. The comparison was performed in a sample of 101 students who are included in the PBL context and a control group with 108 students who participated in a course with non-active methodology. Attitude characteristics, the control locus and the entrepreneurial profile were evaluated. The type of study was exploratory, with a quantitative approach and comparison using the control group using the analysis through the structural equations with the SmartPLS. It was verified that the course that uses an active methodology was able to predict the entrepreneurial behavior in 65.2% in relation to the course that does not use active methodology (58.8%). Among the factors that most favor the entrepreneurial behavior in the course that used active methodology are: self-actualization (21.56%), innovation (16.76%), leadership (9.73%), being sociable (8.41%), and planning (5.26%). Thus, it can be seen that the use of active methodology influences effectively the student's entrepreneurial behavior.

Keywords: Active Methodology, Traditional Methodology, Control Group, Entrepreneurial Behavior.

Resultados da Metodologia Ativa no Comportamento Empreendedor: um Estudo Realizado com Grupo Controle

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Resumo

O objetivo geral deste estudo foi identificar como o uso da metodologia ativa de aprendizagem influi no comportamento empreendedor. Para alcançar este objetivo foi realizado uma comparação entre um curso que utiliza uma metodologia ativa via PBL (*Problem Based Learning*) e outro que emprega uma metodologia não ativa de ensino. A comparação foi realizada em uma amostra de 101 alunos que estão inseridos no contexto PBL e um grupo controle com 108 alunos que participaram de um curso com metodologia não ativa. Foram avaliadas como características atitudinais, o *lócus* de controle e o perfil empreendedor. O tipo de estudo foi exploratório, com abordagem quantitativa e comparação via grupo controle usando a análise por meio das equações estruturais com o *SmartPLS*. Verificou-se que o curso que utiliza uma metodologia ativa conseguiu predizer o comportamento empreendedor em 65,2% em relação ao curso que não usa metodologia ativa (58,8%). Entre os fatores que mais favorecem o comportamento empreendedor no curso que utilizou metodologia ativa estão: a auto realização (21,56%), a inovação (16,76%), a liderança (9,73%), ser sociável (8,41%), e o planejamento (5,26%). Assim pode-se perceber que o uso de metodologia ativa influência de maneira efetiva o comportamento empreendedor do estudante.

Palavras-Chave: Metodologia Ativa, Metodologia Tradicional, Grupo Controle, Comportamento Empreendedor.

1 Introdução

O atual panorama brasileiro é marcado pelos altos índices de desemprego. De acordo com a Pesquisa Nacional por Amostra de Domicílios Contínua, realizada pelo Instituto Brasileiro de Geografia e Estatística - IBGE (2017), a taxa de desemprego do primeiro trimestre do ano de 2017 foi de 14,2 milhões de desempregados, sendo 1,7% superior ao último trimestre de 2016. Em um cenário incerto sobre as possibilidades de emprego, o empreendedorismo, surge como uma opção para muitos brasileiros. A vontade de ter seu próprio negócio, ser o próprio chefe, estimula muitas pessoas, seja por oportunidade de momento ou necessidade circunstancial. Empreender passa a ser uma alternativa para a geração do trabalho autônomo e para a formação da classe empresarial local, criando novas opções de produtos e serviços para a sociedade (Paiva Jr. & Cordeiro, 2002).

De acordo com Shaver & Scott (1992) no processo de empreendedorismo, é necessário levar em consideração vários fatores: marketing, situações econômicas, capacidade de financiamento e fatores governamentais, na qual nenhum dos fatores tem a capacidade de individualmente ser responsável pela criação de um novo empreendimento. Porém também existem fatores mais pessoais. Assim, o comportamento empreendedor possui forte relação não apenas com questões externas, explicado na literatura como Lócus Externo, mas também com questões relacionadas ao indivíduo como o seu Lócus Interno.

Em uma pesquisa sobre o empreendedorismo em 2015, a *Entrepreneurship Monitor* (GEM, 2015), um dos principais responsáveis por pesquisar sobre o tema mundialmente, revelaram que existem fatores que potencializam ou inibem as iniciativas de se empreender, mas o estar envolvido em estágio inicial aumenta substancialmente o desenvolvimento do perfil empreendedor (Gem, 2015)

Há alguns anos as universidades estão adaptando seus currículos e as metodologias ativas vêm ganhando espaço no contexto da educação. Morán (2015), explica que os métodos tradicionais, que usam a transmissão do conhecimento já não fazem sentido, pois o acesso à informação passou a ser fácil e a tecnologia permite integração do aprender e ensinar. Em 2016, Zhou, *et al*. (2016), realizou um estudo de meta análises com 419 Pesquisas, apresentando 419 casos de sucesso com efeito positivo. Porém as necessidades dos currículos se transformaram, demandando atualizações nos conteúdos e formas de ensino. Desde 2011, a Universidade de Brasília-UnB, adota em seu curso de Graduação Engenharia da Produção a metodologia ativa de Aprendizagem por meio de projetos, que são construídos a partir de um problema levantando pela sociedade. Embora o intuito inicial do projeto tenha sido o de melhorar a aprendizagem dos alunos, os projetos realizados em sala de aula pelos discentes têm revelado similaridades com os processos de empreendedorismo citados por alguns autores relevantes (Hisrich & Peters, 2004; Shane & Venkataraman, 2000; Dornelas, 2008).

Porém, apesar da percepção dos professores e estudantes do curso nos feedbacks promovidos ao fim das disciplinas, formalizar uma pesquisa para saber se a metodologia ativa influencia no comportamento empreendedor se faz necessária. Assim o problema desta pesquisa foi:

A adoção de uma metodologia ativa influencia no comportamento empreendedor do estudante?

Este estudo é importante, pois tendo em vista o cenário no qual os índices de desemprego estão cada vez maiores no Brasil, o empreendedorismo surge como importante ferramenta para a criação de emprego e renda da população. Dessa maneira, conhecer se o atual desenho via metodologias ativas contribui para a continuidade do uso da proposta ou a mudança no direcionamento para incluir este importante conteúdo.

Assim, o objetivo deste estudo foi identificar se o uso da metodologia ativa de aprendizagem influi no comportamento empreendedor. Para alcançar este objetivo foi realizada uma pesquisa exploratória com dois grupos, um que aplica metodologia ativa e outro que não, com o intuito de realizar uma análise quantitativa do comportamento empreendedor dos dois grupos. Para isso foi utilizado um modelo adaptado de Xavier (2005), Bohnenberger, Schmidt & Freitas (2007) e Maciel & Camargo (2010), analisado por meio da técnica de equações estruturais.

2 Fundamentação teórica

2.1 Empreendedorismo

De acordo com Fillion (1999) a primeira definição da palavra empreendedorismo teria surgido no século XVIII, por Richard Cantillon, que definiu o empreendedor como um indivíduo que comprava e vendia algo com o objetivo de revendê-lo a um preço superior. Em Dornelas (2007), empreendedorismo é realizar algo novo, buscando sempre por novas oportunidades, com foco em inovar e a criar valor. Seriam várias as definições para empreendedorismo, mas o alicerce pode ser resumido em fazer diferente, utilizando os recursos disponíveis de forma inovadora e também assumindo riscos. De acordo com Shane, Locke e Collins (2003) o empreendedorismo não é somente resultado da ação humana, pois fatores internos do dia-a-dia da empresa podem ser influenciados por fatores externos. Ou seja, os processos que a empresa executa diariamente podem ser influenciados por fatores que não competem à empresa, como por exemplo, situações de mercado, de governo ou questões ambientais. Isso ajuda a determinar a permanência ou não da empresa no mercado.

É importante ressaltar que o empreendedorismo não deve estar associado somente com a criação de um negócio e sim a criação de algo novo, de valor, portanto, empreendedorismo não se resume a criação de novas organizações (Shane & Venkataraman, 2000; Dornelas, 2008). O Empreendedorismo possui em sua formação, duas características consideradas como base: a criação de ideias e a intenção empreendedora. As ideias possuem forte relação com as vontades pessoais, enquanto que as intenções empreendedoras são consideradas fundamentais para que seja possível transformar ideias em novos tipos de negócios (Krueger & Carsrud, 1993; Bird 1988).

Segundo Fillion (1999), o empreendedorismo é descrito examinando-se as habilidades, efeitos sociais e econômicos e as características de determinado empreendedor. Dolabela (1999) ressalta também que o termo empreendedorismo é determinado pelos os estudos que possuem relação ao empreendedor. Portanto, pode-se perceber que o empreendedorismo é considerado uma atividade de elevado grau de complexidade e está amplamente relacionado aos indivíduos que exercem tais atividades empreendedoras.

O estudo do perfil empreendedor não é algo novo. Existem diversas revistas acadêmicas internacionais que estudam exclusivamente o tema empreendedorismo, como por exemplo, a *Entrepreneurship Theory and Practice* e *International Entrepreneurship and Management Journal*. No Brasil ainda não há revistas exclusivas para discutir o empreendedorismo, sendo mais comum o assunto estar relacionado a revistas de Administração. De acordo com Bohnenberger, Schmidt & Freitas (2007), para ampliar a base conceitual sobre o Perfil Empreendedor (PE), é necessário analisar as características atitudinais do empreendedor.

2.2 Comportamento Empreendedor

Existem diversas características identificadas sobre comportamento empreendedor na literatura. Bohnenberger, Schmidt e Freitas (2007), integram 6 características recorrentes na literatura, são elas: ser auto realizador, líder, planejador, inovador, assumir riscos e ser sociável. Ser auto realizador pode ser considerada como uma capacidade de cognição de uma pessoa, na qual ela é capaz de mobilizar suas motivações, seus recursos cognitivos e também seus cursos de ação que exercitam todos os controles acerca dos eventos que ocorrem na sua vida (Chen & Greene *et al*., 1998). De acordo com Carvalho e Gonzáles (2006) ser auto realizador é explicar o nível em que uma pessoa crê em suas próprias capacidades para executar uma tarefa. É um traço de personalidade que afeta a motivação para que se realize com sucesso as tarefas, a seleção de uma carreira profissional e também o grau de tolerância para que se enfrente as situações adversas, além de também ser a percepção individual acerca do risco existente. Assim, surge a hipótese:

H_1- Existe influência da auto realização no comportamento empreendedor.

Para Fillion (1999), o comportamento empreendedor possui atitudes como inovação, independência, liderança assim como também a utilização da autoridade formal. Para Souza *et al.* (2016) o estilo de liderança é um atributo essencial do empreendedorismo, sendo um dos fatores decisivos que corroboram para um indivíduo empreender e liderar sua equipe. Deste modo surge a hipótese:

H_2- Existe influência da liderança no comportamento empreendedor.

Fillion (1999) diz que empreendedores não definem situações somente, como também imaginam sobre o que querem atingir no futuro. Sua principal tarefa é na maioria dos casos a de imaginar e traçar o que querem executar, como também de que maneira irão fazê-lo. Seguindo uma linha de pensamento semelhante, Cupertino e Mendonça (2012) retratam que o planejamento é fundamental para desenvolver um novo negócio, pois o mercado por si próprio é sujeito a riscos e crises. Desse modo se não há um planejamento feito de maneira correta, o pequeno empreendedor não estará pronto para atuar em momentos de crise e esse empreendedor passa a fazer parte da triste lista de empresas que não resistem aos cincos primeiros anos de vida. Assim:

H_3- Existe influência em ser planejador no comportamento empreendedor.

Outra característica é ser inovador. Carlend *et al.* (1984) chegam a conclusão de que o empreendedorismo é resultado principalmente de quatro elementos: a personalidade da pessoa, a disposição em inovar, a capacidade de enfrentar riscos e a postura estratégica. Covin & Miles (1999) defendem que o empreendedorismo não pode existir sem inovação. A inovação deve ter um papel de suporte às ações competitivas da organização em relação a criação de novas ideias, experimentações, produtos e processos diferentes das práticas e tecnologias já existentes. Assim, a hipótese é:

H_4- Existe influência em ser inovador no comportamento empreendedor.

De acordo com Drucker (1986), assumir riscos calculados é um fator importante para o empreendedor, pois não se tornam bons empreendedores, pessoas que necessitam contar com a certeza o tempo todo, ou seja, que possuem plena segurança em tudo que realizam. Segundo Henrique e Cunha (2008), a educação empreendedora deve estar focada em desenvolver habilidades que tornem mais fáceis a tomada de decisões, as quais se destacariam a capacidade de inovar, assumir riscos e resolver problemas. Assim surge a hipótese:

H_5- Existe influência em assumir riscos no comportamento empreendedor.

Para Carland *et al.* (1984), ser sociável é outro fator importante, pois este é o agente de relações, responsável por estabelecer um empreendimento, o gerenciando com o objetivo de crescimento e obtenção de resultados.

Assim o empreendedor está sempre transitando em diferentes meios, exercendo a socialização. Para dos Reis *et al.* (2013, p. 240), a definição de empreendedor seria: "o agente econômico, gerente ou proprietário do negócio, que emprega as ações empreendedoras na busca do crescimento empresarial". Assim, surge a hipótese:

H_6- Existe influência em ser sociável no comportamento empreendedor.

Apesar das contribuições de Bohnenberger, Schmidt & Freitas (2007), sobre fatores que influenciam no comportamento empreendedor, a literatura (Maciel & Camargo, 2010), também aportam a presença das questões cognitivas, que dentro da literatura são estabelecidos como Lócus de Controle.

O conceito de Lócus de Controle já é bastante consolidado e de acordo com Maciel e Camargo (2010) esse tema surgiu na Psicologia, onde a partir daí se expandiu para diversas áreas do conhecimento, alcançando a área de empreendedorismo. O termo lócus de controle pode ser compreendido como a crença do indivíduo em relação à quantidade de controle de seu próprio destino, havendo duas principais vertentes quanto a esse conceito: o lócus de controle interno e o lócus de controle externo. O Lócus Interno acredita que os fatores internos são mais responsáveis para controlar o próprio destino, enquanto o Lócus Externo defende que fatores externos a pessoa possui uma maior responsabilidade nesse controle (Maciel & Camargo, 2010).

Wenzel (1993) diz que o lócus de controle é resultado de como uma pessoa percebe a relação de um evento em relação aos seus esforços. Se a relação ficou clara para essa pessoa, é entendido que ele é internamente orientado. Quando a relação não é clara, diz-se que ela é externamente orientada. Nesse caso a pessoa responsabiliza outros fatores pelo sucesso ou fracasso de uma ação em específico. Segundo Smith, Dugan & Trompenaars (1997), o lócus de controle interno é inversamente relacionado ao grau de desenvolvimento de determinada nação, na qual sugere-se que empreendedores de países em desenvolvimento possuam um lócus de controle interno superior ao de empreendedores de países desenvolvidos. Callado, Gomes e Tavares (2006), baseando-se nos estudos sobre o Lócus Interno, resolvem estudar as características dos empreendedores brasileiros nessa ótica, com o objetivo de descrever traços de personalidade, mais precisamente o lócus de controle em estudantes e empreendedores brasileiros. Assim, pode-se perceber a presença de estudos a respeito do tema, surgindo assim as hipóteses:

H_7- Existe influência do Lócus interno no comportamento empreendedor.

H_8- Existe influência do Lócus externo no comportamento empreendedor.

Assim, para compreender os fatores foram utilizadas as escalas de Xavier (2005), Bohnenberger, Schmidt e Freitas (2007), e Maciel e Camargo (2010). A partir dos três modelos utilizados, foi adaptado um modelo próprio formado por 9 variáveis: Auto realização, Liderança, Planejador, Inovador, Assume Riscos, Sociável, Lócus Interno, Lócus Externo e Comportamento Empreendedor. Não se encontrou na literatura trabalhos que explicam as relações entre essas variáveis. Com um modelo de comportamento empreendedor se estabeleceu a aplicação da escala em dois grupos de estudantes, o primeiro com metodologia ativa e o segundo com metodologia não ativa, revelando os efeitos dos métodos de ensino.

3 Métodos

Este trabalho utiliza como base a taxonomia apresentada por Vergara (2000) e segundo o autor há dois aspectos de classificação de pesquisa: quanto aos meios e quanto aos fins. Quanto aos meios, a pesquisa será bibliográfica e de campo. A parte bibliográfica será realizada através do enfoque meta-analítico de Mariano, *et al* (2011), utilizando a base de dados *Web of Science*, no qual foram encontrados 330 estudos sobre Perfil Empreendedor. A pesquisa de campo foi realizada através da aplicação de questionários, cujo objetivo é coletar dados primários. Esses dados foram obtidos tanto de forma *online* quanto presencial.

Quanto aos fins, a pesquisa será descritiva, quantitativa e possui o objetivo de descrever a relação entre as 9 variáveis. Dessa forma será realizada uma análise multivariada nos seguintes fatores: auto realização, capacidade de assumir riscos calculados, ser planejador, ser sociável, inovação, liderança, lócus interno e lócus externo. As variáveis anteriores serão relacionadas com a variável comportamento empreendedor.

Foram selecionados dois cursos, um onde se adota metodologia ativa e outro que não. Segundo o anuário estatístico da UnB (2016) a universidade conta com 37.982 alunos matriculados em cursos de graduação. O curso com metodologia ativa conta com 586 alunos e o de não ativa conta com 532 alunos. Os dois cursos são do mesmo período, noturno. O nível de confiança adotado é de 90%, com um erro amostral de 5%. A população é de aproximadamente 1672 alunos. Foram obtidas 230 respostas, sendo 209 válidas. 108 respostas são referentes a alunos do curso sem metodologia ativa, enquanto 101 respostas são de alunos do curso com metodologia ativa da universidade de Brasília-UnB. Assim, a taxa de resposta foi de 12,5%, sendo considerada satisfatória.

O questionário foi aplicado presencialmente e também através das demais mídias sociais: *facebook, e-mail, whatsapp*. As aplicações presenciais ocorreram na UnB. Todos os questionários foram aplicados entre os dias 10 de maio e 15 de maio de 2017. Todos os questionários solicitavam que os alunos identificassem seu curso.

Utilizou-se as equações estruturais como técnica estatística. Essa técnica trabalha com análise multivariada e usa o programa SmartPLS (*Smart Partial Least Square*). Os dados obtidos nos questionários foram lançados numa planilha de Excel, devidamente organizados para a utilização do programa *SmartPLS*. De acordo com Cepeda e Roldán (2004), o modelo de equações estruturais com PLS é uma técnica estatística multivariada para provar e estimar relações causais a partir de dados estatísticos e as funções qualitativas de causalidade.

O SPLS é uma formula de modelo de equações estruturais e este método modela uma rede causal de variáveis latentes baseado em indicadores (Cepeda & Roldán, 2004). O PLS pode ser entendido como uma sólida compreensão da análise de componentes principais, análise path e regressões (Barclay, Thompson & Higgins, 1995, p. 290).

Foram realizados no modelo, os testes de confiabilidade e validade, assegurando que o modelo e instrumento (questionário) são válidos e confiáveis nos dois grupos (metodologia não ativa – *Fc*=0,82 e metodologia ativa- *Fc*=0,84). O processo desta pesquisa consistiu em calcular dois modelos por meio de equações estruturais, um para metodologias ativas e outro para não ativa e comparar os resultados nos dois grupos. Assim o grupo de metodologia ativa passa a ser o grupo estudado e o de não metodologia ativa o grupo controle.

4 Resultados e Análises

Foram realizadas duas análises do mesmo modelo estrutural, uma para metodologia ativa e outra para metodologia não ativa.

Falk e Miller (1992), dizem que R^2 deve ser maior ou igual a 0,1 para que seja considerado significativo, dessa forma, serão aceitos valores maiores ou iguais a 10%. Após calcular o valor de R^2, percebe-se que este é maior para a metodologia ativa (65,2%) do que para o curso de metodologia não ativa (58,8%). O coeficiente β é a segunda análise a ser realizada para valorar o modelo estrutural. Os valores de β podem ser encontrados na tabela 1. De acordo com Cepeda & Roldán (2004), β pode ser conhecido como peso de regressão padrão e esse coeficiente é considerado satisfatório quando possui valores acima de 0,2.

Tabela 1 – Teste de hipótese

Hipótese		Metodologia não ativa					Metodologia ativa				
		Beta (β)	%	*t de student*	*p value*	Aceita?	Beta (β)	%	*t de student*	*p value*	Suporta?
H1	Auto realização→ Comportamento Empreendedor	0.122	7,0%	1.362	0,173	Não	0.341	21,56%	4,382	0.000	Sim
H2	Liderança→ Comportament	0.127	6,4%	1.440	0,150	Não	0.186	9,73%	2,338	0.020	Sim

Hipótese		Metodologia não ativa					Metodologia ativa				
		Beta (β)	%	*t de student*	*p value*	Aceita?	Beta (β)	%	*t de student*	*p value*	Suporta?
	o Empreendedor										
H3	Planejamento→ Comportamento Empreendedor	0,210	8,93%	3,182	0.001	Sim	0.143	5,26%	2,118	0,035	Sim
H4	Inovador→ Comportamento Empreendedor	0.013	0,37%	0,120	0,905	Não	0.310	16,76%	4,281	0.000	Sim
H5	Riscos→ Comportamento Empreendedor	0.271	16,2%	2,725	0,006	Sim	0.021	0,81%	0,262	0,794	Não
H6	Sociável→ Comportamento Empreendedor	0.296	15,5%	3,832	0.000	Sim	0.217	8,41%	2,937	0,003	Sim
H7	Lócus Interno→ Comportamento Empreendedor	0.051	1,7%	1,327	0,185	Não	0.066	2,45%	0,795	0,427	Não
H8	Lócus Externo→ Comportamento Empreendedor	0.132	2,53%	1,744	0,081	Não	-0.014	0,19%	0,197	0,844	Não

Fonte: própria

Analisando os resultados do β para o curso que emprega metodologia não ativa, verifica-se que a variável independente Planejador possui um β de 0,210 pontos com relação a variável dependente Comportamento Empreendedor, e segundo as definições vistas em Cepeda & Roldán (2004), significa dizer que há uma forte relação entre essas variáveis. As variáveis independentes Risco e Sociável possuíram β de 0,271 e 0,296 respectivamente e também foram consideradas variáveis significantes na relação com a variável dependente Comportamento Empreendedor. Já as variáveis Auto Realização, Líder, Inovador, Sociável, Lócus Interno e Lócus Externo, possuíram β (betas) menores do que 0,2, sendo assim, a relação delas com a variável dependente Comportamento Empreendedor não foi significante nesta ocasião.

Realizando a mesma análise para o curso com metodologia ativa, a variável Auto Realização possuiu β de 0,341 e foi considerada uma variável independente que possui relação com a variável dependente Comportamento Empreendedor. Esse resultado mostra uma grande diferença encontrada entre os dois cursos, na qual na metodologia não ativa, essa mesma variável não foi considerada forte. Além dela, as variáveis Sociável e Inovação também foram consideradas variáveis de fortes relações com a variável dependente Comportamento Empreendedor, possuindo β de 0,217 e de 0,310 respectivamente. As demais variáveis Planejador, Risco, Líder, Lócus Interno e Lócus Externo foram consideradas variáveis com relação insignificante com a variável latente Comportamento Empreendedor.

Os testes realizados com o β no curso sem metodologia ativa, identifica que o Comportamento empreendedor é mais influenciado pelas variáveis Sociável, Risco e Planejador. Enquanto que para o curso com metodologia ativa, o Comportamento empreendedor é mais influenciado pela Auto Realização, Inovação e Sociável. A variável Sociável é a única que possuiu boa influência em ambos os cursos.

Entretanto, a fim de ratificar os resultados encontrados com o Beta, realizou-se um segundo teste para hipóteses, mais regulares na literatura, como *t-student* e *p-value*. Estes testes são feitos via análise de *Bootstrapping*, que permite examinar a estabilidade na qual as estimativas foram oferecidas no PLS (Chin, 1998). Ainda de acordo com Chin (1998), o valor do índice *t-student* deve ser superior a 1,96 e o *p-value* inferior à 0.05, para hipótese de duas caudas. Na tabela 1, pode-se observar os valores para de ambos os cursos.

No curso que usa metodologias ativas os índices de β somente foram superiores a 0,2 em H1, H4 e H6, portanto essas hipóteses foram aceitas. H2 e H3 apresentaram valores de β próximos a 0,2, portanto, nesse caso foi necessário analisar os demais índices. H2 e H3 passaram a serem aceitos, pois seus índices *t-student* foram superiores a 1,96 e seus índices *p value* foram inferiores a 0,05. As demais hipóteses foram rejeitadas por não possuírem índice β próximo a 0,2. No curso que não utiliza metodologia ativa, os índices de β apenas ratificaram o encontrado anteriormente.
Assim, os resultados permitem compreender que existe diferença nas características do perfil empreendedor para o curso que aplica metodologia ativa e o curso que não aplica. Embora em ambos os cursos o fator social tenha sido importante, no curso que se aplica metodologia ativa o fator auto realização e inovação apareceram como mais influentes, enquanto no que não utiliza os fatores mais fortes foram ser planejador e correr riscos. É importante observar que os alunos de metodologias ativas desenvolvem mais habilidades por meio dos projetos, chegando a validar 5 de 8 hipóteses como significantes, enquanto os alunos de metodologia não ativas desenvolvem apenas 3 de 8 das hipóteses levantadas. Pode-se observar que apenas a variável correr riscos foi validada para os alunos da metodologia não ativa em detrimento a ativa. Acredita-se que isto ocorra devido ao número de projetos que os alunos que trabalham com PBL possuem ao longo do curso, diminuindo substancialmente sua percepção de risco, chegando a considerar que ao assumir esta postura estaria abandonando tudo que aprendeu, uma vez que os projetos trabalham com muitas ferramentas de controle, feedback e gestão de riscos. Deste modo acredita-se que os alunos de metodologias ativas veem o risco como falta de uso correto de ferramentas.

5 Considerações finais, limitações e futuras linhas de pesquisa

Essa pesquisa teve como problema "A adoção de uma metodologia ativa influencia no comportamento empreendedor do estudante?". Através dos resultados obtidos, pode-se perceber que existe uma diferença em adotar metodologias ativas no comportamento do empreendedor. Em geral no curso onde se adotou a metodologia ativa teve-se uma explicação melhor do comportamento empreendedor (65,2%) em comparação ao curso que não a utiliza (58,8%). Percebe-se que o uso da metodologia ativa favorece o comportamento para empreender por meio das variáveis auto realização (21,56%), inovação (16,76%), liderança (9,73%), ser sociável (8,41%), e o planejamento (5,26%).

Assim, foi possível alcançar o objetivo geral da pesquisa que era identificar como o uso da metodologia ativa de aprendizagem influi no comportamento empreendedor.

Um dos fatores limitantes da pesquisa foi a baixa adesão de respostas *online*, sendo necessário realizar uma pesquisa presencial nos *Campus*. Pode-se considerar outro fator limitante da pesquisa o fato de não haver na literatura um estudo semelhante para dar mais embasamento a pesquisa, desse modo não foi possível analisar os resultados das hipóteses com nenhum outro estudo acadêmico similar. Sugere-se que estudos posteriores nessa área pesquisem as relações da Família, do Governo e também das universidades, com o Comportamento Empreendedor. Acredita-se que essas variáveis possam influenciar no perfil empreendedor. Também se recomenda que essa pesquisa seja ampliada para outros cursos de graduação da Universidade de Brasília.

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The Commitment of Institutions of Higher Education in the intention of Use of Active Methodologies: Validation of an Instrument through Structural Equations

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Abstract
The process of globalization, new forms of teaching and the insertion of technologies aimed at education required a new type of teacher: prepared and interested in active teaching methodologies. The purpose of this research is to present a validated instrument on the impact of the university's commitment on teacher training and the consequent intention to use the active classroom methodologies. The results show that there is a positive relationship between the "Teacher Training for the use of Active Methodologies" and the "commitment of the Institution of Higher Education (HEI) with teacher training" of 26%. However, contrary to the hypothesis raised, the strongest relation with regard to "Active Teacher Training" was its result with the dimension "Teachers" with a relation of 47% and not with the dimension "Institution". In this sense, teachers' engagement and interest in the use of active methodologies in the classroom is much more relevant in the process of intention to use this methodology than the commitment of Higher Education Institutions themselves.

Keywords: Active Methodologies, Teacher Training, Higher Education Institutions, Structural Equations.

O Compromisso das Instituições do Ensino Superior na intenção de Uso das Metodologias Ativas: Validação de um Instrumento por meio de Equações Estruturais

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Resumo

O processo de globalização, as novas formas de ensino e a inserção das tecnologias direcionadas para a educação exigiram um novo tipo de professor: preparado e interessado em metodologias ativas de ensino. O objetivo dessa pesquisa é apresentar um instrumento validado sobre o impacto do comprometimento da universidade na formação dos docentes e a consequente intenção de uso das metodologias ativas em sala de aula. Os resultados encontrados mostram que existe uma relação positiva entre a "Formação Docente para o uso de Metodologias Ativas" e o "comprometimento da Instituição de Ensino Superior (IES) com a formação do docente", de 26%. Entretanto, ao contrário da hipótese levantada a relação mais forte tendo em vista "Formação Docente Ativa" foi o seu resultado com a dimensão "Professores" com uma relação de 47% e não com a dimensão "Instituição". Nesse sentido, o engajamento e o interesse dos professores em relação ao uso de metodologias ativas em sala de aula é muito mais relevante no processo de intenção de uso dessa metodologia do que o próprio compromisso das Instituições de Ensino Superior.

Keywords: Metodologias Ativas, Formação Docente, Instituições de Ensino Superior, Equações Estruturais.

1 Introdução

O processo de globalização, o surgimento de novas formas de ensino e a inserção das tecnologias direcionadas para a educação exigem, atualmente, um novo tipo de professor. Nesse sentido, o modelo bancário de ensino, que trata o conhecimento como um conjunto de informações transmitidas pelos professores aos alunos, está cada vez mais em desuso.

Uma dessas novas formas de ensino utilizadas hoje é a metodologia ativa e, segundo Larraz et al. (2017), possibilita desenvolver habilidades, competências e atitudes nos estudantes, relacionando conhecimento teórico e empírico. Contudo, o professor universitário que vivencia o contexto educacional brasileiro, nem sempre consegue desenvolvê-la conforme necessário, devido a barreiras históricas, regulatórias, contratuais, operacionais ou físicas. Uma das maneiras de apresentar aos docentes essas novas metodologias, é oferecer formação contínua de suas instituições de ensino de modo que ele se sinta seguro e possa utilizar o método ativo em todas as suas possibilidades. Propõe-se, desse modo, a seguinte questão: O compromisso das Instituições de Ensino Superior na formação do docente com foco nas metodologias ativas, implica o aumento da intenção de uso dessa metodologia em sala de aula?

A importância desta pesquisa está em oportunizar estudos futuros na área, bem como subsidiar as ações das Instituições de Ensino Superior (IES) na condução de seus processos em formação contínua de docentes em metodologias ativas. Como contribuições para o PAEE-ALE 2018, o estudo apresenta um instrumento validado que relaciona o impacto do comprometimento da universidade com a formação dos docentes em metodologias ativas, na intenção de uso dessa prática em sala de aula.

2 Referencial Teórico

2.1 Metodologias Ativas

Os métodos de ensino baseados em aulas expositivas muitas vezes resultam em passividade do aluno em vez de proatividade com o objetivo único da aprovação do estudante no exame final. Consequentemente, a retenção de conteúdo é temporária e a aprendizagem verdadeira não é alcançada. Desse modo, incentivar o uso das metodologias ativas é fundamental para um processo de ensino aprendizagem enriquecedor e edificante. Valente (2013) afirma que diversas estratégias têm sido usadas para promover a aprendizagem ativa dos estudantes e situa que universidades como MIT e Havard que já utilizam estratégias como a sala de aula invertida na qual o aluno passa a ser protagonista e agente de seu aprendizado já apresentam bons resultados. Resultados positivos acerca dessa metodologia também são apresentados por Ruiz-Gallardo *et al,* (2011), que pesquisaram as notas médias dos alunos que aprenderam por meio da metodologia ativa e concluíram que estas são maiores se comparadas às aulas tradicionais, devido ao aumento da motivação, da responsabilidade e da satisfação com esse método de ensino. Os resultados dos estudos sobre metodologias ativas (Gibbs & Coffey, 2004; Ho *et al.*, 2001, Canaleta *et al.*, 2014) indicam que, com este tipo de aprendizagem cooperativa, os alunos desenvolvem e melhoram habilidades transferíveis, tais como negociação, liderança, trabalho em equipe, reflexão além de melhorias no ambiente da sala de aula e suas interações sociais. Entretanto, a aplicação desse método em sala de aula, com resultados positivos, só é possível mediante a formação contínua e adequada do educador.

2.2 Formação Docente em Metodologias Ativas

Metodologias ativas como a aprendizagem baseada em problemas podem ter um grande impacto na aquisição de conhecimento prático, que é um dos objetivos centrais de aprendizagem no campo da formação de professores (Hemker *et al.,* 2017). Nessa perspectiva, recentes estudos da área, sugerem que a falta de formação docente em metodologias ativas pode ser justificada tanto pela carência de oferta dessa formação pelas instituições de ensino (Castillo *et al.,*2017), quanto pela ausência de incentivo das práticas docentes com a aplicação de novos métodos, visto que, atualmente, as publicações de artigos são mais valorizadas institucionalmente do que os resultados positivos de aprendizagem (Bernal *et al.,* 2010).

Kuhnigk *et al.* (2013) apontam que a formação de docentes pode ser eficaz a longo prazo, mesmo quando a participação destes nessas capacitações seja obrigatória. Tanto esses autores quanto Bernal et al. (2010) concluíram que as competências adquiridas nesses cursos parecem ser mantidas quando o conteúdo da capacitação se encaixa nas atividades de ensino dos participantes.

3 Modelo e Hipóteses

A partir de análises bibliométricas realizadas na literatura, percebeu-se que existem estudos que relacionam formação docente e metodologias ativas, porém de forma dispersa. Nesse sentido, será proposto um quadro teórico integrador com as teorias (Morgado 2013) das dimensões que constituem o modelo proposto:

Quadro 1. Quadro teórico integrador: construtos propostos para o modelo

Dimensões	Autor	Premissa
TEMPO	Martins, 2005	A falta de tempo contribui para que os professores sintam que não podem aprender novas abordagens didático-pedagógicas ou se atualizar nos níveis científico, didático e tecnológico.
	Mellado, 2011, Bernal *et al.,* 2010	A falta de interesse do professor em formação se dá por considerarem que ela é pouco relevante para o seu trabalho.
PROGRAMA	Madureira, 2011	As avaliações externas exigem conhecimentos conceituais.
	Madureira, 2011	Os professores consideraram que é mais fácil e rápido implementar o ensino tradicional em sala de aula.
	Martins, 2005; Madureira, 2011	Os professores sentem-se pressionados a cumprirem o programa da disciplina
	Viseu & Morgado, 2011	Os professores não sentem necessidade de elaborar novos materiais didáticos.
PROFESSORES	Fernández *et al.*, 2009	Os professores não têm formação suficiente em novas abordagens didático-pedagógicas.
	Jiménez & Wamba, 2003	Os professores sentem-se inseguros na implementação de novas abordagens de ensino.

Dimensões	Autor	Premissa
	Jiménez & Wamba, 2003	A crença dos professores nas potencialidades de novas abordagens didático-pedagógicas não é suficientemente para implementar a metodologia ativa.
	Formosinho & Araújo, 2011.	A formação docente deve ser inspiradora para experimentarem situações de aprendizagem centradas nos alunos.
	Jiménez & Wamba, 2003	A formação deverá permitir ao professor, não só a atualização dos conhecimentos, mas também mudanças das suas perspectivas sobre o processo de ensino e de aprendizagem.
	Pozo, 2006; Fernández *et al.*, 2009	O docente não poderá incidir novas metodologias de ensino sem antes ter em foco a mudança de suas práticas.
	Jiménez & Wamba, 2003	Para ser eficaz, a formação deve incluir um componente teórico e outr prático, devidamente articulados.
	Pozo, 2006	O componente teórico da formação permitirá ao professor compreender os fundamentos da nova metodologia, suas potencialidades e suas limitações.
	Jiménez & Wamba, 2003; Marcelo, 2009	O componente prático da formação permitirá ao professor aplicar os conhecimentos adquiridos em sua formação.
	Marcelo, 2009	Nas primeiras vezes que o professor implementa uma nova metodologia, é natural que se sinta inseguro.
	Marcelo, 2009	O auxilio de um especialista poderá contribuir para que o professor seja mais receptivo para mudança nas suas práticas.
INSTITUIÇÃO	Valcárcel, 2005 (apud Fernández, 2005)	Cursos recebidos, publicações, participação em inovações pedagógicas e atividades de envolvimento na IES são atividades consideradas pelas instituições como indicador de melhoria docente.
	Martins, 2005	Nem sempre a escola dispõe de condições e recursos para implementarem novas abordagens didático-pedagógicas.
FORMAÇÃO DOCENTE EM METODOLOGIAS ATIVAS (FDA)	Especialistas, 2017	Entrevista com especialistas em PBL aplicado à Engenharia de Produção demonstra resultados do uso de metodologias ativas.
INTENÇÃO DE USO DE METODOLOGIAS ATIVAS (MA)	Venkatesh, Thong & Xu, 2012	Adaptação da teoria UTAUT 2 (*Unified Theory of Acceptance and Useof Technology, UTAUT*) para o ensino.

Fonte: Adaptado *de* Morgado (2013) e Venkatesh et al (2012)

Com o pressuposto de validar um instrumento de pesquisa que relacione a influência do incentivo das Instituições de Ensino Superior na formação docente em metodologias ativas na prática em sala de aula, realizou-se uma interação entre as variáveis *formação docente ativa* e suas influenciadoras (*tempo, programa, professores e instituição*), adaptado de Morgado (2013), incidindo na variável *intenção de uso da metodologia ativa*, adaptado do modelo de Venkatesh *et al.*(2012).

Nessa perspectiva, as hipóteses deste estudo são 6, sendo que primeira responde diretamente ao problema e as demais são antecedentes da formação docente ativa.

- H_1 – Quando as Instituições de Ensino Superior realizam a formação docente em metodologias ativas há aumento na intenção do uso dessa prática em sala de aula.
- H_2 – A formação docente ativa influencia na intenção de uso das metodologias em sala.
- H_3 - A Instituição de Ensino Superior influencia na formação docente em metodologia ativa.

- H_4 - Os professores influenciam na formação docente em metodologia ativa.
- H_5 – O programa influencia na formação docente em metodologia ativa.
- H_6 - O tempo influencia na formação docente em metodologia ativa.

4 Metodologia

Este estudo classifica-se como exploratório, de abordagem quantitativa por meio das equações estruturais. A abrangência de pessoas foi escolhida por conveniência, com o intuito de atingir a maior quantidade de Estados brasileiros possíveis. Como objeto de pesquisa tem- se o estudo das interações entre as variáveis "Formação Docente Ativa" e suas influenciadoras propostas por Morgado (2013) ("Tempo", "Programa", "Professores" e "Instituição"), incidindo na variável intenção de uso da metodologia ativa, adaptado do modelo de Venkatesh *et al.*(2012).

Para tanto, foi organizado um formulário *on-line* com 43 questões como instrumento de coleta de dados. As questões foram fundamentadas e categorizadas em 6 dimensões, a saber: "Tempo" (4 questões), "Programa" (6 questões), "Instituição" (6 questões), "Professores" (13 questões), "Formação Docente Ativa" (7 questões) e, por fim, "Intenção de uso de Metodologias Ativas" (7 questões). Todas as perguntas possuíam a escala de *Likert* de 5 itens como resposta: Discordo; Discordo em parte; Nem concordo, nem discordo; Concordo em Parte; e Concordo. O questionário pode ser acessado no link: https://docs.google.com/forms/d/1kSCp-9gEbtcIs59is1xXM5E_SfSw9Df2tS7lSCMev-E/edit . O público alvo foram professores universitários de IES públicas e privadas brasileiras. O critério para participar da pesquisa foi se utilizam/utilizaram a metodologia ativa em sala de aula. Foram excluídos da pesquisa os questionários preenchidos parcialmente, isto é, incompletos.

A coleta se deu por meio da plataforma *Google Forms* nos meses de maio a junho de 2017. Para realizar a validação de instrumento proposta por este estudo, foi escolhido o programa *Smart*PLS em razão de ser apropriado para realizar estudos em realidades complexas, com múltiplas variáveis e teorias não consolidadas (Hair *et al.* 2017). Segundo Hair, *et al.,* (2011), para uma validação consolidada, a quantidade mínima de amostras para esse procedimento é de 30 questionário e este estudo trabalhou com uma amostra de 53 respondentes. Foram realizadas as etapas de Descrição do Modelo Estrutural, Validação do Modelo Estrutural e Valoração do Modelo Estrutural.

5 Resultados e Discussões

Atendendo a proposta de validação de um instrumento de pesquisa, o primeiro estudo realizado com o questionário foi a etapa de validação semântica, feita por especialista em linguística, garantindo clareza, coerência e objetividade aos indicadores. Na sequência, o instrumento foi aplicado e submetido aos critérios de inclusão e exclusão. De posse dos dados finais, foi aplicado o passo a passo da metodologia proposta por Ramírez, Mariano e Salazar (2014).

5. 1 Descrição do modelo proposto

Conforme esclarecido anteriormente, o modelo é composto por 6 dimensões: Tempo (4 itens), Programa (6 itens), Instituição (6 itens), Professores (13 itens), Formação Docente Ativa (7 itens) e, por fim, Intenção de uso de Metodologias Ativas (7 itens). Na Figura 1, os círculos representam as variáveis latentes e os retângulos, um conjunto de itens (questões) aplicados pelo questionário relacionados à cada uma dessas variáveis latentes, as quais explicam. Desse modo, tem-se: a variável "formação docente em metodologias ativas" e suas influenciadoras ("tempo", "programa", "professores" e "instituição"), incidindo na variável "intenção de uso da metodologia ativa".

5. 2 Validação do Modelo Estrutural

O primeiro passo para atestar a validação do modelo é o teste de confiabilidade de item que calcula as correlações entre as variáveis e seus indicadores. Segundo Hair *et al.* (2017) deve-se depurar os itens com grau inferior a 0,5, desde que não comprometa a AVE e a confiabilidade composta, por estes não serem considerados confiáveis.

Conforme Figura 1, alguns indicadores com índice abaixo de 0,6 foram desconsiderados por não terem atingido o grau mínimo de 0,5. Foram eles: Tempo (T1 e T4) Instituição (Inst6), Programa (Prog1, Prog5, Prog6), Professores (P1,P2,P6,P9,P11,P12,P13) Formação Docente Ativa (FDA1, FDA3, FDA5).

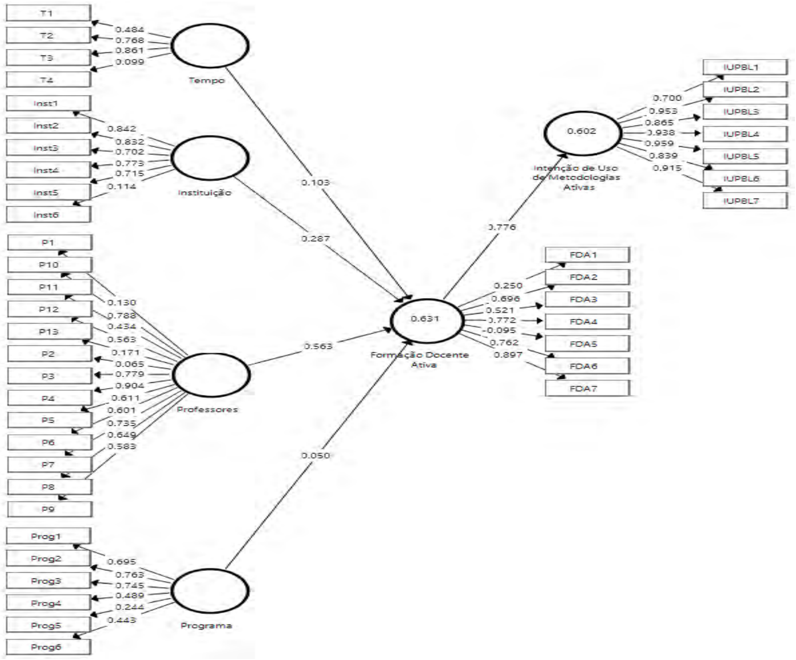

Figura 1 – Modelo de equações estruturais

Fonte: Imagem extraída software *Smart*PLS 3.0

Após a depuração do modelo, todos os demais itens apresentaram confiabilidade dentro do índice exigido, evidenciando que estavam correlacionados e explicavam a variável latente à qual estavam relacionados. Para tanto, considerou-se válido e confiável, no presente modelo, o construto cujo resultado tenha sido superior a 0,7 (Ramírez, Mariano & Salazar, 2014), o que pode ser constatado na Figura 2, demonstrada na seção 5.3 – Valoração do Modelo Estrutural. Pode-se observar, na Tabela 3, que o modelo proposto atendeu tal requisito (*Alfa de Cronbach*, rho_A) e apresentou confiabilidade composta média de de fc= 0,89.

Para expressar a validade das variáveis latentes, foi calculada a Variância Média Extraída (AVE), que confirmou que os indicadores interferem apenas na variável proposta, sem incidirem nas outras variáveis apresentadas. Para o AVE, o índice adequado deveria ser igual ou superior a 0,5, indicando que mais de 50% da variância apresentada se devia aos indicadores associados. Conforme Tabela 1, observa-se que todos os fatores se mostraram acima de 0,5, comprovando a validade convergente dos construtos (Ramírez, Mariano & Salazar, 2014); todos os AVE encontrados estão acima dessa faixa:

Tabela 1- Tabela testes de Confiabilidade interna, Validade Convergente, Multicolinearidade e Efeitos Indiretos.

Variáveis	**Alfa de Cronbach**	**rho_A**	**Confiabilidade composta**	**Variância Média Extraída (AVE)**	**VIF**
FDA	0,816	0,843	0,879	0,647	1,000
Instituição	0,838	0,881	0,878	0,591	1,173
Intenção de Uso de MA	0,953	0,968	0,962	0,784	----
Professores	0,877	0,909	0,909	0,628	1,331
Programa	0,732	0,746	0,848	0,651	1,116
Tempo	0,734	0,758	0,881	0,788	1,215

Fonte: própria. Extraído de SmartPLS

O teste de Inflação Interna da Variança (VIF) foi realizado para evitar a ocorrência da influência de um dado de uma variável em outra e não poderia apresentar valores superiores a 10, para evitar problema de multicolinearidade (Ramírez, Mariano & Salazar, 2014), o que também foi atendido. Por fim, era necessário se ter a confirmação de quanto um construto se diferenciava do outro, sem se sobreporem. Para que fosse válido, o teste de validade discriminante deveria apresentar raiz quadrada de AVE, de cada variável latente, maior do que as demais variáveis latentes do modelo, conforme apresentado na tabela 2 (Ramírez, Mariano & Salazar, 2014).

Tabela 2- Validade Discriminante (Critério de Fornell-Larcker)

Variáveis	FDA	Instituição	Intenção de Uso de MA	Professores	Programa	Tempo
FDA	**0,80**					
Instituição	0,43	**0,77**				
Intenção de Uso de MA	0,78	0,36	**0,89**			
Professores	0,65	0,29	0,68	**0,79**		
Programa	0,24	-0,11	0,03	0,24	**0,81**	
Tempo	0,41	0,29	0,35	0,36	-0,04	**0,89**

Fonte: própria. Extraído de SmartPLS

Desse modo, após todas as análises e testes, chegou-se a um modelo estrutural válido e confiável visto atender aos parâmetros propostos pela literatura que embasou o presente estudo.

5.3 Valoração do Modelo Estrutural

A valoração do modelo estrutural realiza a análise das relações e seus resultados de predição, com a contribuição das variáveis independentes sobre as dependentes.

O primeiro índice de valoração dos resultados é a predição, ou seja, quanto a variável dependente é predita pelas demais. Segundo Cepeda & Roldán (2004), o R2 indica a porcentagem em que um construto anterior prediz a variável dependente. Com base no estudo de Hair, *et al.*, (2017), o cálculo para a variância da variável endógena (R2) deve ser maior ou igual a 0,1, para que seja considerado significante, isto é, se aceita valores acima de 10% de predição.

Neste estudo, observou-se que a variável dependente *formação docente ativa* foi explicada em 52,3% pelos construtos Tempo, Instituição, Professores e Programa. Do mesmo modo, a *formação docente ativa* predisse *Intenção de Uso de Metodologias ativas* em 60,6% sendo ambos os valores de predição considerados satisfatórios, conforme demonstra a Figura 2.

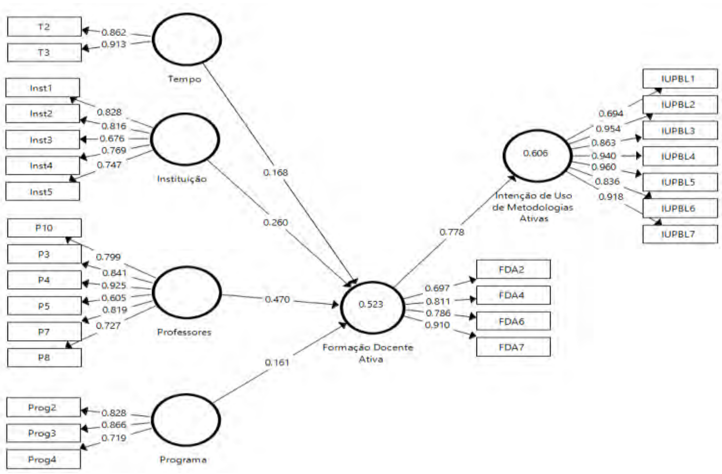

Figura 2 – Modelo de equações estruturais

Fonte: Imagem extraída software *Smart*PLS 3.0

Também foi avaliado o coeficiente de *patch Beta (β ≥ 0,2)*, para realizar a validade de cada hipótese proposta. Para que o Beta tivesse significância, ele deveria ser superior ou igual a 0,2 (Ramírez, Mariano & Salazar, 2014).

Em Equações Estruturais via variância (como o SPLS), existe uma ratificação para assegurar maior confiabilidade a confirmação das hipóteses, que ocorre por meio da análise de *Bootstrapping*. O *Bootstrapping* oferece dois resultados, o teste t de *student* e o *p-value*. Para este tipo de estudo é necessário que se cumpram duas prerrogativas; valores de t de *student* superiores a 1,96 e de *p-value* inferiores a 0,05 (Ramírez, Mariano & Salazar, 2014).

Conforme Tabela 3, três variáveis foram suportadas por apresentarem valores de Beta superiores a 0,2, sendo ratificadas pelos valores de t de *student* superiores de 1,96 e *p-value* abaixo de 0,05. Ao contrário, as hipóteses H5 e H6 não obtiveram relações significativas, não cumprindo os critérios de Beta, t de *student* e *p-value,* portanto, não foram suportadas.

Tabela 3- Beta, % da influência, teste *t de student* e *p value*

Hipóteses	**Beta**	**%**	***t de student***	***p-value***	**Hipótese Aceita**
Formação Docente Ativa -> Intenção de Uso de MA	0,778	60,58%	8,324	0,000	Suportada
Instituição -> Formação Docente Ativa	0,260	11,15%	2,444	0,015	Suportada
Professores -> Formação Docente Ativa	0,470	30,44%	3,107	0,002	Suportada
Programa -> Formação Docente Ativa	0,161	3,89%	**1,254**	**0,210**	**Não suportada**
Tempo -> Formação Docente Ativa	0,168	6,87%	**1,002**	**0,316**	**Não suportada**

Fonte: própria. Extraído de SmartPLS

A variável "Formação Docente Ativa" gerou uma "Intenção de Uso de Metodologias Ativas" em 60,58%, aceitando, desse modo, a hipótese sugerida. Também foram aceitas as hipóteses de Instituição -> Formação Docente Ativa, com 11,15% e Professores -> Formação Docente Ativa, com 30,44%. As hipóteses programa e tempo como influenciadoras do uso de metodologias ativas foram negadas com Beta abaixo de 0,2 com 3,89% e 6,87%. Pode-se perceber, com os resultados, que a relação mais forte apresentada no modelo apareceu entre o professor e a formação docente ativa. Esta, somada à relação da instituição, tempo e programa, impactaram em 60,6% na Intenção de uso de metodologias ativas em sala de aula. Desse modo, entendeu-se que realizar ações e formações que abarquem as necessidades e os interesses dos professores pode fazer com que eles se engajem para o uso de metodologias ativas em sala de aula.

6 Conclusão

Após os testes de validade e confiabilidade do instrumento de coleta deste estudo, por meio do programa *Smart*PLS, foi possível responder ao problema de pesquisa e validar as hipóteses propostas. Para o problema apresentado - O compromisso das Instituições de Ensino Superior, púbicas e privadas, na formação do docente com foco nas metodologias ativas implica a intenção do uso dessa metodologia em sala de aula? -, observou-se que existe uma relação positiva de 26% entre a *Formação Docente Ativa* e a *Instituição de Ensino Superior (IES)*. Entretanto, a relação mais forte, tendo em vista *Formação docente Ativa*, foi o seu resultado com a dimensão "Professores", com 47%. Por fim, é possível dizer que a "Formação Docente Ativa" associada às quatro dimensões apresentadas (Tempo, Instituição, Professores e Programa) respondem em 60,6% a "Intenção de Uso da Metodologia Ativa" em sala de aula. A H1 obteve uma relação positiva de 26% e uma relação final de 60,6% para a intenção de uso de metodologias ativas em sala de aula. A H2 e H3 apresentaram uma relação negativa com 16,8% e 16,1%, H4 uma relação positiva com 47% e, por fim, a H5 com uma relação positiva explicando o modelo em 60,6%. Nesse sentido as contribuições deste trabalho estão em propor que, numa escala de trabalho institucional, para mobilização da adoção da metodologia ativa nas IES públicas e privadas, é necessário estar atento primeiro à dimensão Professores, seguidas das dimensões Instituição, Tempo e Programa.

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Horizontal and Vertical Structure for Project-Approach Engineering Curriculum

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Abstract

In Engineering curricula of São Judas University (Brazil) was adopted a Project-Approach structure that is leaded by the discipline "Interdisciplinary Projects", which is present in all semesters and culminating in the Final Graduation Project (developed in the two final semesters). Curricular matrix and project themes are planned both horizontally (with projects inserted in the context of the areas of knowledge addressed by the other disciplines of each semester) and vertically (each semester, new concepts related to project management are introduced cumulatively). Projects use the methodological approach known as CDIO (Conceive, Design, Implement, Operate) and, although all the semesters use this same methodology, each semester, more management and project monitoring tools are introduced. The planning, monitoring and management tools are part of the process evaluation carried out during the semester, which together with the final product assessment will compose the final grade. In the initial semesters, the students have a logbook that must be presented weekly in follow-up project meetings. Next periods, new concepts are added, deployed and used, in order to improve students' abilities in project management. Starting with the weekly tracking notebook and having continuity with others tools such as mental maps, Ishikawa Diagrams, Work Breakdown Structure (WBS), Gantt Chart, Product Tree, Business Canvas. Activities are run using free softwares and apps like Trello, Simple Mind, Gantter for Google Drive.

Keywords: Active Learning, CDIO, Engineering Curriculum, Project-Approach Engineering Education, Project Management

Organização Horizontal e Vertical em Currículos de Engenharia Conduzidos por Projetos

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Resumo

Na estrutura curricular aplicada aos cursos de engenharia da Universidade São Judas, o aprendizado por meio de Projetos, com a disciplina "Projetos Interdisciplinares" é feito desde o início do curso, culminando com o Trabalho de Conclusão de Curso, desenvolvido nos dois semestres finais. A matriz curricular e os temas dos projetos são planejados tanto horizontalmente, com os projetos inseridos no contexto das áreas de conhecimentos abordados pelas demais disciplinas de cada semestre, mas também verticalmente, de forma que a cada semestre novos conceitos relativos à gestão de projetos são introduzidos de forma cumulativa. Os projetos utilizam a linha metodológica conhecida como CDIO (Conceive, Design, Implement, Operate) e, embora todos os semestres utilizem esta mesma metodologia, a cada semestre vão sendo introduzidas ferramentas de gestão e acompanhamento de projetos, na execução dos projetos pelos alunos. As ferramentas de planejamento, acompanhamento e gestão fazem parte da avaliação processual, realizada ao longo do semestre, que, junto com a avaliação do produto final, comporá a nota da disciplina. Nos semestres iniciais, os alunos possuem um caderno de registros que deve ser apresentado semanalmente com o acompanhamento do projeto. A cada semestre, novas ferramentas são implantadas e utilizadas nos semestres seguintes, iniciando pelo caderno de acompanhamento semanal, mapas mentais, Estrutura Analítica de Projeto (EAP), gráfico de Gantt, Árvore de produtos, *Canvas* de modelo de negócios. As atividades são executadas utilizando ferramentas gratuitas, como Trello, Simple Mind, Gantter.

Palavras-chave: Aprendizagem Ativa, CDIO, Currículo em Engenharia, Educação em Engenharia conduzida por Projetos, Gestão de Projetos

1 Introdução

Desde 2015, a matriz curricular dos cursos de Engenharia das Instituições de Ensino Superior (IES) do grupo Ânima, incluindo a Universidade São Judas Tadeu, tem em sua organização a componente curricular chamada Projeto Interdisciplinar (PI). A disciplina tem por objetivo colocar em prática, desde o início do curso, os conhecimentos desenvolvidos ao longo de cada semestre. Ao propor projetos baseados em situações reais, respeitando o nível de aprendizado, o aluno pode conectar os conhecimentos teóricos, dando sentido e significado ao que está sendo aprendido (Weenk & Blij, 2012). A disciplina está presente em todos os semestres do curso, exceto nos dois últimos, nos quais os alunos desenvolvem seu Trabalho de Conclusão de Curso.

A disciplina é parte fundamental no Projeto Acadêmico dos Cursos de Engenharia, pois, além de tratar de temas reais que conectam os conhecimentos teóricos, traz ao estudante a possibilidade de trabalhar diversas habilidades como a capacidade de lidar e resolver problemas, espírito crítico, capacidade de análise, trabalho em equipe, autonomia, criatividade, comunicação oral e escrita, além de adquirir conhecimentos sobre a sua área de atuação profissional (Ânima, 2016).

Ao usar os projetos como forma de aprofundar o que está sendo aprendido, o aluno adquire também a possibilidade de um aprendizado que não se limita a reproduzir ou listar características, mas que permite relacionar e abstrair conhecimentos e ir além do que foi ministrado, de acordo com suas características e interesses (Biggs & Tang, 2011).

A estruturação da disciplina Projeto Interdisciplinar é feita tanto no sentido "horizontal", isto é, relacionando os projetos aos conteúdos ministrados nas disciplinas teóricas, quanto no sentido "vertical", ao introduzir progressivamente conceitos e ferramentas de gestão de projetos, e também provocando a reflexão sobre o papel do profissional inserido na sociedade, tornando-se peça importante no Projeto Pedagógico dos Cursos, que tem como objetivo a formação de um profissional que seja também um cidadão consciente, crítico e responsável (Annala & Mäkinen, 2011).

Na matriz curricular adotada para os cursos de Engenharia, os quatro primeiros semestres constituem a parte de Formação Básica e é comum a todos os cursos, sendo obrigatoriamente cursados de forma sequencial. A partir do quinto semestre tem-se a Formação Específica, de acordo com a modalidade escolhida (Engenharia Civil, Controle e Automação, Elétrica, Eletrônica, Mecânica, Química e Produção), com estrutura modular (A e B). Na organização modular dos cursos, cada módulo possui um eixo temático específico, que permite que os alunos cursem os módulos (A ou B) na ordem que desejarem, visto que não há pré-requisitos entre módulos. Assim, o aluno pode, por exemplo, cursar o módulo 5A antes do módulo 5B ou vice-versa. O mesmo vale para os módulos 6 e 7.

2 Estruturação Horizontal dos Currículos e Projetos Interdisciplinares

Os Projetos Pedagógicos dos cursos de Engenharia foram construídos de forma que os conteúdos e as disciplinas ministradas sejam organizadas de forma a contribuir, cada qual dentro da sua visão, com o desenvolvimento da formação do profissional, de acordo com o perfil de egresso desejado. A primeira etapa na construção da proposta de projeto deve ocorrer de forma coletiva entre os professores das disciplinas do semestre. A elaboração criativa de temas de projeto se inicia com um *canvas*, desenvolvido a partir de construção de modelos de negócios (Ostenwalder & Pigneur, 2010), mas adaptado ao desenvolvimento de projetos educacionais (Navarro & Marques, 2017). A figura 1 abaixo mostra o modelo utilizado.

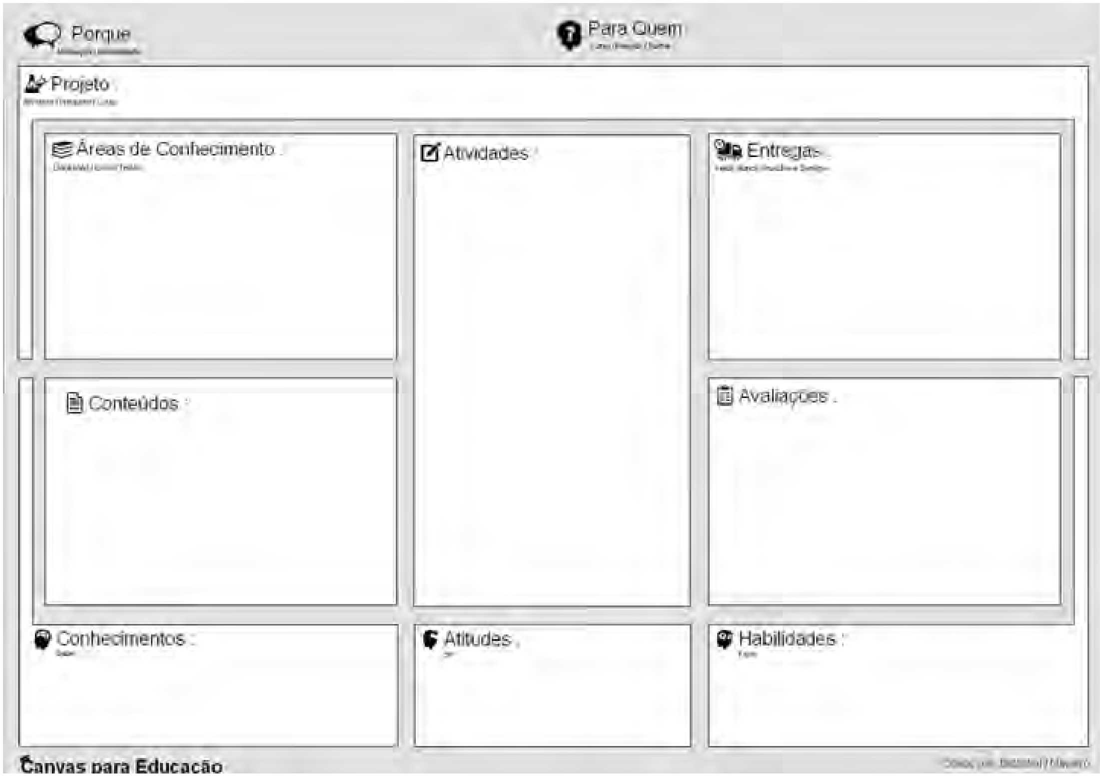

Figura 1: Canvas Educacional para projetos (Navarro & Marques, 2017)

Esse *canvas* é o passo inicial da elaboração de projetos de forma horizontal, relacionando conhecimentos, habilidades e atitudes que se desejam desenvolver no semestre, os conteúdos relacionados às áreas de conhecimento para definir o tema do projeto e as formas de avaliação e entregas a serem realizadas.

Embora nem sempre presente, o envolvimento dos professores de todas as disciplinas é fundamental, tanto na concepção da proposta, quanto no acompanhamento dos projetos e também, eventualmente, modificando a abordagem de conteúdos, ajustando-as às necessidades dos projetos.

Os projetos, podem ser classificados em quatro tipos:

- Dirigidos: São propostas de projeto que partem de problemas reais (ou adaptação de um problema real), no qual os grupos devem desenvolver uma solução para o problema. Ao final do semestre, comparando as diversas soluções, os grupos podem refletir e discutir sobre as possibilidades apresentadas;
- Temáticos: Os grupos devem desenvolver o trabalho em torno de um tema específico, como fontes alternativas de energia ou soluções para o abastecimento de água numa cidade;
- Competitivos: Cada grupo constrói um produto que irá participar de alguma competição, por exemplo Ponte de Espaguete ou Máquinas de Rube Goldberg.
- Livres: Usualmente, Livre escolha dos alunos, passando pela aprovação do orientador no início do projeto.

Os projetos interdisciplinares são, em geral, dirigidos ou temáticos. Projetos competitivos são realizados em situações específicas de curta duração e os projetos livre são os Trabalhos de Conclusão de Curso. Exemplo de projeto dirigido já realizado é o controle de transporte de carga movimentada por motor de corrente contínua. Projetos temáticos já realizados, foram o já citado sobre fontes alternativas de energia e também sobre as formas da Natureza na Engenharia.

3 A Estruturação Vertical dos Projetos Interdisciplinares

Além de integrar a disciplina PI ao semestre em que está inserida, é importante que exista uma evolução nos projetos, não só em termos de conteúdo e complexidade, mas também no que se refere às ferramentas de gestão.

No início do curso, os estudantes não estão acostumados e não percebem a importância do planejamento e do acompanhamento e do registro da evolução do projeto. É natural que exista uma certa ansiedade em montar e testar, sem se preocuparem com o planejamento e com o registro do projeto.

A primeira ferramenta utilizada, já no primeiro semestre, é o Cronograma, com indicação de datas e entregas. No primeiro momento os alunos recebem, acompanham e obedecem aos eventos e datas presentes do cronograma; a segunda ferramenta é um Caderno de Acompanhamento (ou Diário de Bordo), que consiste num registro no qual o grupo deve indicar a data, as atividades desenvolvidas na semana anterior, comparando com o que era planejado e justificando a importância da atividade, acrescido de um relato sobre os conhecimentos das demais disciplinas que ele utilizou para executar a atividade. Este campo é importante para que os alunos percebam, a cada momento do projeto, que estão acionando conhecimento das outras disciplinas e dando significado ao que foi aprendido. No último campo, o grupo preenche com as ações a serem desenvolvidas na próxima semana, mostrando a importância do planejamento das atividades. O caderno é verificado semanalmente pelo professor orientador, mas fica em posse dos alunos durante o semestre, sendo entregue como parte do portfólio ao final do semestre.

Os desenhos de projeto, memorial de cálculo, caderno de acompanhamento semanal e o registro fotográfico da montagem irão compor, ao final do semestre, o Portfólio de Projeto, que comporão parte da avaliação processual.

No terceiro semestre, após a definição do projeto, o grupo deverá montar a Estrutura Analítica do Projeto (EAP), em inglês *Work Breakdown Structure* (*WBS*). EAP é a estruturação dos trabalhos e entregas de um projeto em partes menores, de fácil gerenciamento (PMI, 2017).

Ao construir previamente a EAP, o aluno deve pensar nas etapas de trabalho a serem executadas, nas entregas solicitadas (Desenhos, Cálculos, Seminários, montagens parcial e final, relatório etc), enfim, o grupo deve visualizar todo o projeto e planejar a duração e as tarefas e responsabilidades de cada membro do projeto.

A partir do 4o semestre, após a confecção do EAP, os alunos são orientados a preencher um Gráfico de Gantt. No gráfico constam os prazos e os responsáveis de cada tarefa. Ele permite, tanto para o professor quanto para os estudantes, acompanhar a evolução do projeto (White & Fortune, 2002). Atualmente existem ferramentas gratuitas *on-line* que permitem a visualização e edição compartilhada dos gráficos de Gantt.

No 5o e 6o semestres (Módulos 5A e 5B) agregam-se às ferramentas anteriores as análises PERT/CPM, utilizadas como ferramenta de planejamento de projetos, determinando melhores caminhos e coordenação de atividades relacionadas ao projeto.

Nos semestres seguintes (Módulos 6A e 6B), os alunos devem construir *canvas* de negócios no modelo desenvolvido por Ostenwalder (2002, op. cit.) com o objetivo de olhar o produto desenvolvido como uma possível perspectiva de negócio, mostrando um olhar além da perspectiva acadêmica e incentivando o espírito empreendedor.

A intenção é que esses elementos de gestão e acompanhamento de projetos estejam presentes durante o Trabalho de Conclusão de Curso e que os alunos possam considerar as perspectivas acadêmica e comercial ao escolher o tema de seu trabalho final e que possam, no exercício profissional, aplicar esses conceitos.

A figura 2, abaixo, mostra de forma resumida a estrutura curricular, acompanhada dos elementos de projeto e quando são adotados para os alunos e também as entregas que compõem a avaliação do projeto.

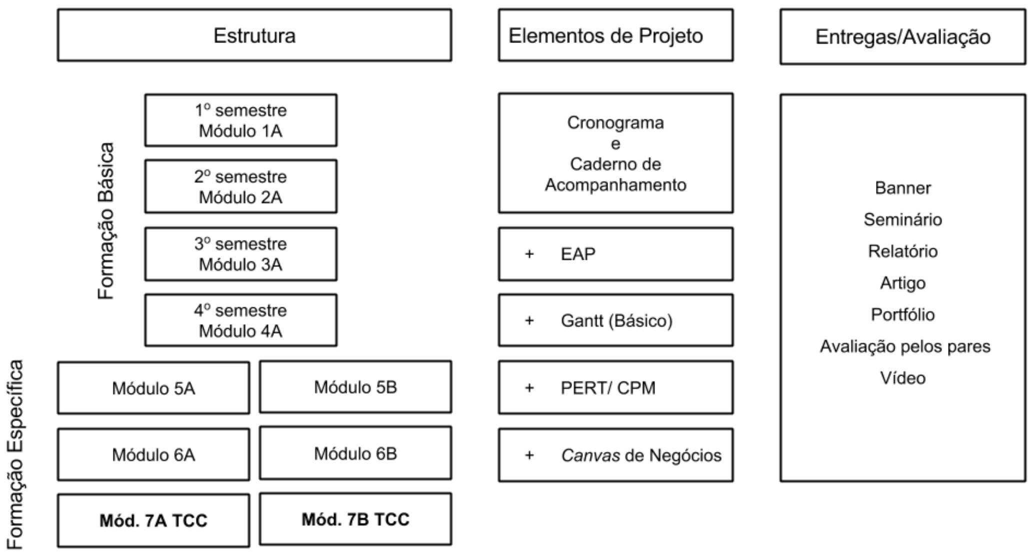

Figura 2: Estrutura curricular, elementos de projeto e instrumentos de avaliação

4 Avaliação

Uma parte importante do processo de ensino e aprendizagem é o alinhamento dos métodos de avaliação aos objetivos estabelecidos e declarados para o curso (Biggs & Tang, 2011).

A avaliação dos Projetos Interdisciplinares é composta por duas etapas: uma processual, que avalia a evolução do projeto ao longo do semestre e outra final, que consiste na avaliação do resultado obtido pelo grupo.

Para a avaliação processual são utilizados vários instrumentos, aplicados ao longo do semestre, que têm a função de propiciar ao professor o acompanhamento e a orientação dos projetos

- Cronograma
- Caderno de Acompanhamento (Diário de Bordo)
- Estrutura Analítica do Projeto (a partir do 3º semestre)
- Gráfico de Gantt (a partir do 4º semestre)
- Banner
- Seminário
- Avaliação pelos pares, que pode ser aplicada à apresentação dos Seminários ou à apresentação dos banners
- Portfólio do projeto, construído ao longo do semestre pelas Folhas de Acompanhamento Semanal, Memorial de cálculos, Desenho do Projeto, Cronograma
- Vídeo (apresentação do produto em vídeo)

A avaliação pelos pares é importante à medida em que engaja os estudantes no seu processo de aprendizagem, propiciando maior espírito crítico e maior compreensão do próprio processo de aprendizagem (Searby & Ewers, 2006). Ao se estabelecerem vários critérios claros e bem compreendidos de avaliação, esta se torna mais objetiva. Falchikov and Goldfinch (2000) mostram a validade do processo tanto em anos iniciais, quando em estágios mais avançados, mostrando também um alinhamento nas avaliações feitas por pares e as realizadas por professores. Nesse sentido, o ganho de visão crítica e de engajamento justifica plenamente a adoção da avaliação pelos pares.

Para realizar essa avaliação, o professor deve estabelecer os critérios e esclarecer os objetivos de forma a tornar o aluno consciente do processo que está realizando (Falchinov & Goldfinch, op cit.). A estratégia utilizada na universidade São Judas é a utilização de Ferramentas gratuitas de preenchimento de formulários, adotando a Escala Likert (de 1 a 5) para itens objetivos. Como exemplo, podemos citar a avaliação dos banners, na qual os alunos avaliam:

- Formatação do Banner (está de acordo com o *Template*?)
- Adequação do título do projeto ao produto final proposto
- Clareza no texto (objetivos, apresentação, medidas,conclusões)

Além disso, os alunos devem citar dois pontos positivos no trabalho do colega e dois pontos a serem melhorados, essas últimas questões ajudam o aluno a formar uma opinião mais crítica e refletida do que simplesmente dar conceitos. Essa avaliação por pares é realizada antes da apresentação final do trabalho. Dessa forma, ao receberam o os resultados, os grupos têm a possibilidade de modificar e melhorar a versão final do banner, que é a que será exposta ao público.

A avaliação final consiste basicamente na apresentação do produto (ou protótipo), em geral feita para a classe, junto com uma Banca Examinadora, composta pelo professor orientador e por mais dois professores da área. Também consta da avaliação final uma parte escrita, que pode ser um relatório ou na forma de um artigo científico. Essas duas formas de apresentação escrita se alternam a cada semestre, possibilitando que os alunos exercitem diferentes formas de linguagem, seja acadêmica ou aplicada ao exercício profissional.

5 Conclusões

Como as grades estão sendo implantadas progressivamente desde 2015, ainda não temos uma turma formada que tenha passado por todas as etapas descritas neste artigo. Até o presente momento, os alunos demonstram grande interesse e adesão às ferramentas. Embora inicialmente o Caderno de Acompanhamento seja visto mais como uma tarefa e menos como uma ferramenta necessária, os alunos vão, aos poucos, entendendo a importância das ferramentas e valorizando o seu uso.

Até o momento, foram desenvolvidos projetos temáticos, projetos dirigidos e, em casos específicos, projetos propostos pelos próprios alunos. Os estudantes têm, em muitos casos, implantado melhorias que não estão nas especificações iniciais, superando expectativas e demonstrando, na maioria das vezes, autonomia e interesse em aprender além do que é ministrado. Esse engajamento no próprio processo de aprendizagem ultrapassa os limites da simples transmissão de conhecimentos e torna o processo mais significativo e efetivo. A aprendizagem torna-se profunda e os alunos aprendem a importância dos fundamentos teóricos (Biggs & Tang, op. cit.).

Os portfólios de projeto têm sido outra parte importante, visto que trata-se de um histórico das atividades do aluno durante a sua graduação, que pode ser um diferencial importante para a colocação desse aluno no mercado.

Alguns professores têm experimentado ferramentas *on line* como *drivers* e aplicativos (inclusive para dispositivos móveis) compartilhados entre professor e alunos, de forma que todas as entregas (exceto o produto final) sejam acessadas a qualquer momento, inclusive após o término do curso, compondo um portfólio eletrônico do projeto.

Para os próximos semestres há a necessidade de implantar conceitos de custos e perspectivas de mercado para os produtos desenvolvidos. A conceituação teórica dos elementos de gestão gestão de projeto também não pode ser esquecida.

A metodologia CDIO tem se mostrado eficiente e suficientemente simples e clara para alunos iniciantes e, espera-se, completa o suficiente para estudantes em estágios mais avançados. Os processos de avaliação e autoavaliação, alinhados aos objetivos de cada Projeto Interdisciplinar, deve ser compreendida como uma maneira de incentivar o aprendizado significativo. assim, ainda há um espaço de discussão importante a ser considerado pelos professores, tanto na avaliação dos projetos, quanto na avaliação das demais disciplinas.

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Assessment Models in Two Project Based Learning (PBL) Approaches: an exploratory study

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Abstract

Project Based Learning approach (PBL) has been a curricular and pedagogical asset in several engineering programs. According to the literature, PBL is based on a project being developed by teams of students in order to solve a problem connected with the profession, linking theory and practice. This learning context create opportunities for students to develop a set of technical and transversal competences related to engineering professional practice. In PBL there is no universal models, but a diversity of approaches. They are similar by the main principles of PBL, but different by the way they happen in practice. Implementing PBL implies rethinking the teaching and learning approach, in terms of contents, faculty collaboration, pedagogical spaces, and strategies for students' support, amongst other. Particularly, assessment has been widely discussed in several studies. In order to contribute for an in-deep reflection about this topic, this paper aim to present two PBL assessment models in different contexts: a) PIEGI – Master Degree in Industrial Engineering and Management at University of Minho, Portugal; b) 100% PBL model in Engineering courses at UNISAL, Lorena, SP, Brazil. The assessment model in both contexts were analysed, based on documental analysis (pedagogical documents related to the projects). The information was organized and analysed in order to identify differences and similarities in both models. Implications of assessment in PBL and practical recommendation are presented in order to provide more inputs about this topic.

Keywords: Project-Based Learning; Assessment; Engineering Education.

Modelos de Avaliação em Duas Abordagens de Aprendizagem Baseada em Projetos (PBL): um estudo exploratório

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Resumo

A Aprendizagem Baseada em Projetos (Project-Based Learning – PBL) tem sido uma aposta curricular e pedagógica em diversos cursos de Engenharia. De acordo com a literatura da especialidade, o PBL pode ser entendido como um projeto desenvolvido por equipas de alunos que visa a resolução de um problema ligado à profissão, permitindo uma articulação entre a teoria e a prática. Este contexto de aprendizagem possibilita que os alunos desenvolvam um conjunto de competências técnicas e transversais fundamentais para a prática profissional em Engenharia. Poder-se-á afirmar que não existem modelos PBL universais, mas uma diversidade de modelos que se assemelham, pelos princípios em que assentam e que, simultaneamente, se distinguem pela forma como acontecem na prática. A implementação do PBL implica, repensar a forma de ensinar e aprender, nomeadamente no que diz respeito aos conteúdos a serem explorados, formas de colaboração docente, criação de espaços pedagógicos, estratégias de apoio aos alunos, entre outros. De uma forma particular, a avaliação tem sido objeto de diversos estudos pela complexidade das questões que acarreta. No sentido de contribuir para uma reflexão mais aprofundada nesta temática, este estudo tem como objetivo apresentar dois modelos de avaliação em dois contextos PBL distintos: PIEGI - Mestrado Integrado em Engenharia e Gestão Industrial da Universidade do Minho, Portugal, e Modelo 100% PBL em disciplina nas Engenharias da Unisal Lorena, SP, Brasil. Para a realização deste estudo, a recolha de dados foi realizada através de análise documental (e.g. documentos pedagógicos relacionados com os projetos) cuja organização e análise da informação permitiu identificar as diferenças e as semelhanças dos dois modelos de avaliação PBL. Partindo desta descrição, pretende-se explorar as implicações da avaliação em PBL, bem como apresentar um conjunto de recomendações práticas capazes de ampliar a discussão sobre a temática.

Palavras-Chave: Aprendizagem Baseada em Projetos; Avaliação; Educação em Engenharia

1 Introdução

A mudança de paradigma no contexto da Educação em Engenharia torna-se cada vez mais urgente e necessária, particularmente na forma como os professores ensina e como os alunos aprendem. A prática profissional em Engenharia requere uma articulação entre competências técnicas e transversais, de forma a encontrar soluções rápidas e eficazes para problemas complexos. Este contexto reforça a necessidade numa mudança de paradigma educacional, assente na criação de experiências de aprendizagem significativas que possibilitem a formação integral do aluno (Zabalza, 2009), isto é, oportunidades de desenvolvimento de competências transversais a par das competências técnicas, tais como: trabalhar em equipas multidisciplinares, comunicar em diferentes contextos, pesquisar e encontrar soluções criativas e inovadoras (Lima, Mesquita, Rocha, & Rabelo, 2017).

Uma das respostas a estes desafios educacionais é a aprendizagem ativa que se caracteriza pela criação de experiências de aprendizagem com relevância para o aluno, na medida em que a implementação de estratégias de aprendizagem ativa (de que é exemplo a sala de aula invertida, *think pair share*, entre outras) amplia a oportunidade de articulação entre a teoria e a prática com vista ao desenvolvimento de competências fundamentais para a prática profissional (Christie & de Graaff, 2017; Mesquita, Lima, Flores, Marinho-Araujo, & Rabelo, 2015). Adicionalmente, os ambientes de aprendizagem ativa conduzem a um maior envolvimento, entusiasmo por parte dos alunos e ainda regulação no seu próprio processo de aprendizagem (Stolk, Martello, Somerville, & Geddes, 2010).

De acordo com os dados relatados por 225 estudos analisados por Freeman et al. (2014), a aprendizagem ativa aumenta o desempenho nos exames e as aulas expositivas ("lectures") aumentam a taxa de falha em 55%.

A Aprendizagem Baseada em Projetos (Project-Based Learning – PBL) tem sido uma aposta curricular e pedagógica em diversos cursos de Engenharia. Caracteriza-se, fundamentalmente, pelos seguintes princípios (Graaff & Kolmos, 2003; Powell & Weenk, 2003):

- Problema: é o elemento norteador da abordagem PBL. O problema do projeto deve estar relacionado com o contexto profissional de engenharia, no sentido a conferir à aprendizagem mais relevância e significado, nomeadamente na aplicação do conhecimento nesse mesmo contexto. Deve ainda ser um problema aberto, no sentido de promover processos de criatividade, inovação, tomada de decisão ao longo do desenvolvimento do projeto. Assim, o projeto não apresenta uma solução única e fechada, mas sim a possibilidade de várias soluções para o mesmo problema.

- Interdisciplinaridade: é o elemento diferenciador da abordagem PBL. Considerando a natureza do problema, o projeto terá necessariamente uma natureza interdisciplinar, possibilitando um contexto de aprendizagem que permite aos alunos não só ligar a teoria e a prática, como estabelecer ligações entre as diferentes áreas do conhecimento (Cálculo com Programação, por exemplo).

- Trabalho em equipa: é o elemento decisivo da abordagem PBL. Sem equipas não há projeto. Não só os alunos têm de ser capazes de trabalhar de forma colaborativa, como também os professores envolvidos no projeto.

Poder-se-á afirmar que não existem modelos PBL universais, mas uma diversidade de modelos que se assemelham pelos princípios em que assentam e que, simultaneamente, se distinguem pela forma como acontecem na prática. Existem, por isso, diferentes tipologias de projeto (Helle, Tynjälä, & Olkinuora, 2006).

Nas abordagens PBL podem identificar-se quatro tipos fundamentais de projetos. Projetos desenvolvidos com uma parte de uma disciplina (1). Projetos desenvolvidos como a totalidade de uma disciplina (2). Projetos que integram de forma interdisciplinar várias disciplinas (3). Finalmente, poderá pensar-se numa estrutura sem disciplinas em que um projeto substitui todas as disciplinas num determinado momento do currículo (4).

Independentemente da tipologia em questão, a implementação do PBL implica repensar os conteúdos a serem explorados, as formas de colaboração docente, a criação de espaços pedagógicos, as estratégias de apoio aos alunos e, de uma forma particular, a avaliação tem sido objeto de diversos estudos pela complexidade das questões que acarreta (Fernandes, Flores, & Lima, 2012a, 2012b; Lima, Mesquita, Fernandes, Marinho-Araújo, & Rabelo, 2015).

Este estudo tem como objetivo descrever dois modelos PBL de dois contextos distintos (PIEGI - Mestrado Integrado em Engenharia e Gestão Industrial da Universidade do Minho, Portugal e Modelo 100% PBL em disciplina nas Engenharias do Unisal Lorena, SP, Brasil) dando particular enfoque ao modelo de avaliação utilizado em ambos os contextos. Para a realização deste estudo, a recolha de dados foi realizada através de análise documental (e.g. documentos pedagógicos relacionados com os projetos) cuja organização e análise da informação permitiu identificar as diferenças e as semelhanças dos dois modelos de avaliação PBL. Trata-se de um estudo exploratório que, a partir da descrição realizada, visa explorar as implicações da avaliação no PBL, bem como apresentar um conjunto de recomendações práticas capazes de ampliar a discussão sobre a temática.

2 Dois contextos PBL, Dois modelos de avaliação

As abordagens PBL (Project Based Learning) têm por essência o desenvolvimento do aprendizado conceitual do estudante através da prática de projetos, onde o aluno passa a ser protagonista no direcionamento do seu aprendizado. O professor continua tendo um papel fundamental neste contexto, ele passa a ser um mediador, e dessa forma a direcionar o aprendizado. Saber avaliar nesta nova modalidade é de fundamental importância.

2.1 Contexto 1: PBL@MIEGI – UMINHO, Portugal

As abordagens de PBL implementadas no MIEGI (Lima, Dinis-Carvalho, Sousa, Alves, et al., 2017) têm um conjunto de características comuns e variam em alguns aspetos contextuais, relacionados com o semestre específico em que são implementados. Nesta descrição resumida, serão focadas as características comuns e em seguida, as especificidades do projeto implementado no semestre 7 do curso.

Todos os projetos do MIEGI têm em comum uma disciplina, denominada "Projeto Integrado em Engenharia e Gestão Industrial #" (PIEGI#). O número # vai variando de forma sequencial ao longo do curso. Deve notar-se que o projeto será uma de 6 disciplinas do semestre, todas com a mesma carga relativa. Ainda característica destas abordagens será o facto de o projeto ser baseado na integração entre as disciplinas (na totalidade ou parcialmente) do mesmo semestre do projeto, e existir um modelo de acompanhamento por parte de professores dessas disciplinas. Além disso, todos os projetos são desenvolvidos por equipas de dimensão variável, conforme o projeto.

Quanto ao modelo de avaliação, este vai variando em função do projeto. Neste caso particular, vai-se estudar o modelo do projeto do semestre 7, do PIEGI2 (Lima, Dinis-Carvalho, Sousa, Arezes, & Mesquita, 2017). Neste projeto, realizado durante 17 semanas em interação com empresas, as equipas analisam e desenvolvem propostas de melhoria para o sistema de produção de empresas industriais. O projeto inicia-se com a apresentação por parte de representantes da empresa do problema a analisar. Durante o resto do semestre, as equipas deslocam-se à empresa uma vez por semana. Num outro dia da semana trabalham na universidade e os professores das várias disciplinas deslocam-se aos seus espaços de projeto para levantarem questões direcionadoras e tirarem dúvidas.

Nesta abordagem PBL, os projetos desenvolvidos por equipas de 9 a 11 elementos são avaliados de forma sumativa em função de 2 tipos de elemento: apresentações e relatórios. Realizam-se 3 apresentações durante o semestre, na semana 6, 11 e 17. A entrega de relatórios, sempre sob a forma de artigos, realiza-se nas semanas 11 e 17. A entrega de relatórios é complementada pelos blogs que os alunos vão produzindo ao longo do semestre. A primeira apresentação (5% da nota final) será sobre o estado do andamento do projeto, esperando-se uma perspetiva sobre a empresa e o problema e tratar. A segunda apresentação (10%) e primeiro relatório (20%) será sobre a análise do problema e algumas propostas iniciais de melhoria. A terceira apresentação (15%) e segundo relatório (50%) serão avaliados fundamentalmente quanto às propostas de melhoria. Neste modelo de avaliação, os protótipos são avaliados diretamente apenas nas disciplinas de apoio ao projeto e indiretamente através dos relatórios. A Figura 5 apresenta os critérios gerais de avaliação utilizados para as apresentações e para os relatórios (incluindo os blogs).

Critérios	Peso
1. Estrutura da Apresentação e Apresentação Gráfica	20%
2. Comunicação	25%
3. Criatividade	25%
4. Conteúdos	30%

Critérios	Peso
Adequação do Trabalho aos Objectivos	15%
Fundamentação e Rigor Conceptual	40%
Capacidade de Reflexão e Análise Crítica	10%
Estrutura e Apresentação Gráfica	15%
Respeito pelas Regras de Referenciação Bibliográfica	15%
Cumprimento de Prazos e de Condições de Entrega	5%

Figura 5. Critérios de avaliação para as apresentações e relatórios, respetivamente.

Este modelo de avaliação atribui uma nota à equipa de projeto. Para distinguir individualmente os elementos da equipa, utiliza-se um modelo de avaliação pelos pares dentro da equipa. Neste modelo, os alunos vão atribuindo um peso relativo de cada um dos elementos em relação a uma média da equipa. Todas avaliações peer dentro e uma equipa terão que ter média 1.0, e um estudante com maior contribuição do que os outros terá uma nota acima e outro com menor contribuição terá uma nota abaixo (Fernandes et al., 2009; Vicente, Romano, Sá, & Lima, 2014). Nesta abordagem os alunos têm liberdade para negociar com os docentes a forma de implementação do modelo de avaliação, seguindo três abordagens alternativas: avaliação aberta por consenso; avaliação igual para todos; avaliação anónima. Na Figura 6 apresenta-se um exemplo hipotético de avaliação anónima realizada pelo aluno 1 em relação aos seus 10 colegas. Considerando todas as avaliações será possível calcular aqueles elementos que são considerados pelos colegas como tendo um contributo superior aos outros, e aqueles que são considerados como tendo contributos inferiores. Desta forma, o valor calculado será multiplicado pela nota de equipa para se calcular o valor final da nota individual.

Escala de 1 a 10											
Grupo#											
Perceção do elemento	1										
Relativamente aos outros elementos no critério:	1	2	3	4	5	6	7	8	9	10	11
Assiduidade e pontualidade	9	9	8	10	9	9	10	10	9	9	7
Criatividade	10	10	9	9	9	10	9	10	10	9	10
Entreajuda	10	10	10	10	10	10	10	10	10	10	10
Correta realização das tarefas e entrega no	10	10	10	10	10	10	10	10	10	10	10
Empenho	10	10	10	10	10	10	10	10	10	10	10
Espírito critico	10	9	9	9	10	10	9	10	9	10	9
Total	59	58	56	58	58	59	58	60	58	58	56

Figura 6. Exemplo de critérios utilizados pelas equipas na avaliação pelos pares

A maior parte do processo de avaliação pode considerar-se formativo, na medida em que todas as semanas os alunos recebem feedback por parte dos diversos professores que estão a acompanhar o projeto. Além disso, existem entregas iniciais de plano de projeto que são avaliadas apenas formativamente, e após todas as entregas ao longo do semestre as equipas recebem feedback formativo.

2.2 Contexto 2: PBL@Engenharias – UNISAL, Brasil

No Unisal, o PBL trabalhado nas Engenharias foi adaptado do Modelo de formação de Olin College Of Engineering, Neeedham MA, EUA e do modelo da Universidade do Minho, Portugal (Lima, Dinis-Carvalho, Flores, & Hattum-Janssen, 2007; Lima, Dinis-Carvalho, Sousa, Alves, et al., 2017), tendo estes modelos sido estudados e adaptados para a realidade da instituição, nomeadamente considerando o perfil do aluno, os recursos disponibilizados, a organização dos cursos, entre outros aspetos.

No UNISAL os cursos de Engenharia trabalham, desde 2013, com a Disciplina de Mecânica dos Fluidos no modelo 100% PBL e desde a sua criação e implementação há uma preocupação com o modelo de avaliação.

Inicialmente implementou-se a disciplina 100% PBL com o modelo de avaliação contínua, sendo que semanalmente, durante todo o semestre (aproximadamente 15 semanas) os alunos recebem atividades a serem realizadas em grupo ou individualmente para compor a nota do semestre e a outra parte da avaliação é composta por três projetos. Assim também se trabalha habilidades e competências, tais como gestão de problemas, trabalho em equipe, gestão do tempo, criatividade, etc..

Os projetos são avaliados dentro de critérios estabelecidos e divididos em: Apresentação de Projetos, Protótipo, e Relatório e mostrados na Figura 7.

	Critérios	Projeto 1 (0 a 10)	Projeto 2 (0 a 10)	Projeto 3 (0 a 10)
Apresentação	Comunicação			
	Postura			
	Participação dos membros			
Protótipo	Qualidade e esmero na construção			
	Criatividade			
	Relevância			
Relatório	Fundamentação Teórica			
	Dados e cálculos do protótipo			
	Reflexão e análise crítica			
	Formatação e organização da estrutura			
	Adequação aos objetivos			

Figura 7. Tabela de Avaliação de Projetos

Os alunos fazem ainda uma auto avaliação como mostra a Figura 8.

Como está a qualidade dos nosso trabalho? (Aproveitem para "dar uma olhada nos trabalhos das demais equipes")					
Como nos sentimos acerca do nosso envolvimento (engajamento) com o projeto					
Protótipo construído; como ficou?					
E sobre a nossa capacidade de planejamento e coordenação?					
Como foi o relacionamento do nosso grupo?					
Adquirimos conhecimentos?					
Como foi minha percepção acerca do aprendizado da matéria?					

Figura 8. Planilha de autoavaliação.

Neste modelo os alunos podem observar como trabalharam e a qualidade do trabalho apresentado por seu grupo e comparar com a apresentação dos demais colegas. A auto avaliação ainda proporciona uma reflexão em grupo sobre a gestão realizada no desenvolvimento do Projeto.

Ao trabalhar com a avaliação individual continuada sobre atividades realizadas semanalmente e também com a avaliação em grupo através dos projetos, cria-se uma maior conectividade e proximidade com os alunos o que permite desenvolver as competências que precisam ser exploras tais como:

1) Competências de Gestão de Projetos: Capacidade de Investigação, Capacidade de Decisão, Gestão de Tempo
2)Competências de Trabalho em Equipe: Autonomia, iniciativa, responsabilidade, liderança, resolução de problemas
3)Relacionamento Interpessoal: motivação e Gestão de Conflitos

4)Competências de Desenvolvimento Pessoal: criatividade e originalidade, espírito crítico, auto avaliação

5) Competências de Comunicação: comunicação escrita e oral

Os projetos são apresentados em forma de protótipo e através de apresentação oral como mostra a Figura 9.

Figura 9. Projetos de Mecânica dos Fluidos 100% PBL

Dessa maneira procura-se aumentar a participação e o engajamento dos alunos nas aulas e nas atividades de maneira a envolve-los na pesquisa e busca por conceitos da ementa para aplicação na construção do projeto.

3 Considerações Finais

Este artigo apresenta um estudo exploratório em que se analisaram dois contextos de PBL e os respetivos modelos de avaliação, com vista a identificar os aspetos em que se destacam e em que se distinguem, promovendo, assim, uma reflexão sobre as formas de avaliação em abordagens PBL.

No Mestrado Integrado em Engenharia e Gestão Industrial da Universidade do Minho, o Projeto Integrado em Engenharia e Gestão Industrial apresenta uma abordagem interdisciplinar, envolvendo as diferentes disciplinas do semestre. Assim, a avaliação sumativa do projeto comporta um cariz interdependente, na medida em que contribui para a avaliação das disciplinas de apoio ao projeto. Adicionalmente, a avaliação sumativa deriva da concretização dos relatórios e apresentações realizadas ao longo do projeto. Particular atenção é dada aos momentos de avaliação formativa, nomeadamente o acompanhamento aos alunos durante o semestre.

No UNISAL, Lorena, desde o início da implementação PBL na disciplina de Mecânica dos Fluidos, pode-se observar um envolvimento crescente por parte dos alunos com o processo de ensino e aprendizagem. Os projetos foram encorpando e se desenvolvendo de maneira mais criativa e com mais aplicações conceituais a cada semestre. Em termos de avaliação, atenção especial é dada às atividades que medem a participação e aprendizagem individual dos alunos, assim como no desenvolvimento das atividades em grupo.

De referir que em ambos os contextos são consideradas, de forma intencional, as competências que se esperam que os alunos desenvolvam em ambiente de projeto. Em termos de trabalho futuro espera-se sistematizar e detalhar cada um dos modelos de avaliação, considerando a abordagem de avaliação para a aprendizagem.

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Application of the Project Based Learning approach in the maintenance of General Eletric Aviation's aeronautical turbines

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Abstract

This study integrates a more comprehensive research, called here a major research, whose central question is: How to apply the Project Based Learning (PBL) approach in a graduation course of production engineering? It presents the application of the initial model of the PBL approach in Production Engineering, proposed by the larger research, in one of the disciplines of the Synthesis and Integration content group that composes the backbone and conductive line of the Production Engineering training of the first Graduation School of Engineering of Petrópolis, Federal Fluminense University. This group is mainly responsible for the learning of contents related to the design, execution, control, improvement and innovation of production systems and encompasses aspects of synthesis, integration and entrepreneurship. The application of the PBL approach was carried out in the discipline Project of Production System I (PPS I) that aims to enable the student to develop skills and abilities related to the realization of a group project; The use of communication and expression techniques; and the application of methods, techniques and procedures of the scientific methodology in production engineering. In the context of a case study at the company Avio do Brazil, controlled by GE Celma and both belonging to General Electric Aviation, a problem situation was defined by the partner organization and developed by the students of the PPS I discipline, with three projects to assist in its solution. The main result of this study was: the optimization of the flow of parts of the various processes of the maintenance program of one of the aeronautical turbines maintained by the partner organization, applying the PBL approach.

Keywords: Active Learning; Engineering Education; Project Approaches, maintenance, aeronautical turbines.

Aplicação da abordagem Project Based Learning na manutenção de turbinas aeronáuticas da General Eletric Aviation

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Resumo

Esse estudo integra uma pesquisa mais abrangente, chamada aqui de pesquisa maior, cuja a questão central é: Como aplicar a abordagem Project Based Learning (PBL) em um curso de graduação de engenharia de produção? Ele apresenta a aplicação do modelo inicial da abordagem PBL em Engenharia de Produção, proposto pela pesquisa maior, numa das disciplinas do grupo de conteúdos Síntese e Integração que compõe a espinha dorsal e linha condutora da formação em Engenharia de Produção do primeiro curso de graduação da Escola de Engenharia de Petrópolis da Universidade Federal Fluminense. Esse grupo é o principal responsável pela aprendizagem dos conteúdos relativos ao projeto, execução, controle, melhoria e inovação de sistemas de produção e engloba aspectos de síntese, integração e empreendedorismo. A aplicação da abordagem PBL foi realizada na disciplina Projeto de Sistema de Produção I (PSP I) que tem como objetivo capacitar o aluno a desenvolver competências e habilidades: relativas a realização de projeto em grupo; a utilização de técnicas de comunicação e expressão; e a aplicação de métodos, técnicas e procedimentos da metodologia científica em engenharia de produção. No âmbito de um estudo de caso na empresa Avio do Brasil, controlada pela GE Celma e, ambas pertencentes à General Electric Aviation, uma situação problema foi definida pela organização parceira e desenvolvido pelos alunos da disciplina PSP I três projetos para ajudar na sua solução. O principal resultado desse estudo foi a otimização do fluxo de peças dos vários processos do programa de manutenção de uma das turbinas aeronáuticas manutenidas pela Avio do Brasil, utilizando a abordagem PBL.

Palavras-chave: Active Learning; Engineering Education; Project Approaches, maintenance, aeronautical turbines.

1 Introdução

O século XXI é caracterizado por profundas mudanças nos campos cultural, social e tecnológico e para enfrentar esses desafios as organizações estão buscando engenheiros com competências e habilidades que normalmente não são desenvolvidas pelos modelos tradicionais de ensino. Nesse contexto, as metodologias ativas de aprendizagem podem ajudar a superar esses desafios, pois estimulam os alunos a desenvolverem competências técnicas interdisciplinares e habilidades de comunicação e gerenciamento (Christie & de Graaff, 2017; Lima, Andersson & Saalman, 2017a). No ensino de Engenharia, aprender apenas por meio de problemas apresentados em salas de aulas com soluções previamente conhecidas já não é suficiente, pois os problemas atuais das organizações requerem dos engenheiros a capacidade para transferir ou aplicar conhecimentos a novas situações, por meio de comunicação e trabalho em equipe (Puente, Jongeneelen & Perrenet, 2011).

Entre as diversas metodologias ativas de aprendizagem existentes, uma das mais utilizada na educação em engenharia é a abordagem Project Based Learning. No exterior, algumas universidades destacam-se na utilização dessa abordagem: University of Illinois at Urbana-Champaign, University of Nottinghan, Aalborg University e Universidade do Minho, sendo que a Aalborg University é a única que utiliza currículos totalmente orientados para projetos (da Silva et al., 2017).

No Brasil, a Escola de Engenharia de Lorena da USP e a Faculdade de Tecnologia da UnB destacam-se pela a aplicação da abordagem Project Based Learning em seus cursos de Engenharia de Produção.

O curso de Engenharia de Produção da Escola de Engenharia de Petrópolis da UFF iniciou suas atividades em novembro de 2015 com carga horária total de 3660 h, distribuídas proporcionalmente em dez semestres em turno integral. O curso oferece cinquenta vagas semestrais e atualmente são disponibilizadas disciplinas do 1º ao 6º. Período. Na elaboração do Projeto Pedagógico do Curso (PPC), as experiências de outras universidades na aplicação da abordagem Project Based Learning foram estudadas e consideradas, sendo que a principal referência utilizada foi o PPC do curso de Engenharia de Produção da Faculdade de Tecnologia da UnB (UnB, 2014). O modelo da UnB foi modificado e adaptado as especificidades do curso que está sendo implantado na UFF em Petrópolis.

Esse artigo tem como objetivo apresentar a aplicação da abordagem Project Based Learning em uma das disciplinas do curso de Engenharia de Produção da UFF em Petrópolis. Essa abordagem foi utilizada para otimizar o fluxo de peças do processo de manutenção de uma das turbinas aeronáuticas manutenidas pela empresa Avio do Brasil, controlada pela GE Celma e, ambas pertencentes à General Electric Aviation.

No item 2 é apresentado o referencial teórico sobre Project Based Learning e manutenção de turbinas aeronáuticas. No item 3 é apresentada a metodologia de pesquisa empregada no estudo. No item 4 são apresentados os resultados da aplicação da abordagem para otimizar o fluxo de peças no processo de manutenção e no item 5 são apresentadas as conclusões do estudo.

2 Referencial teórico

Nos próximos subitens é apresentada uma revisão de literatura sobre a aplicação da abordagem Project Based Learning e manutenção de turbinas aeronáuticas.

2.1 Project Based Learning

As experiências com as abordagens Problem Based Learning e Project Based Learning no ensino de engenharia têm aumentado nos últimos anos, e seus resultados parecem ser melhores do que outras abordagens educacionais em uso (Tavares, De Campos & De Campos, 2014).

A abordagem Problem Based Learning vem sendo utilizada no ensino superior desde dos anos de 1960 e tem permitido aos alunos a construção de uma base mais ampla e coesa de competências e habilidades adaptáveis a suas necessidades (Amador, Miles & Peters, 2006). Nessa abordagem o aprendizado é realizado por meio de pequenas tarefas com soluções fechadas para dificuldades conhecidas, com acesso simultâneo a múltiplos conhecimentos e a aprendizagem ativa, com duração de uma a duas semanas para análise e/ou solução de cada problema apresentado. Essa abordagem parte da proposição de uma questão elaborada pelos professores, que leva os alunos a coletarem dados e informações (fatos), a gerarem ideias e a identificarem suas necessidades de aprendizado, cuja busca por respostas (supervisionada pelos professores) lhes possibilitam formular hipóteses e fornecer explicações e/ou sugestões de solução para o problema, com um resultado final não previamente esperado (Tavares, De Campos & De Campos, 2014).

Já a abordagem Project Based Learning é focada em grandes tarefas, com dificuldades crescentes, soluções abertas e questões desafiadoras, com as quais os grupos de alunos criam produtos, processos ou sistemas, analisam e aplicam teorias no seu desenvolvimento (Weenk & Van Der Blij, 2011; Powell & Weenk, 2003). Com uma duração de dez ou mais semanas para desenvolvimento de um projeto proposto, essa abordagem parte da proposição de um tema de projeto sugerido pelos professores, visando o desenvolvimento de um produto, artefato, protótipo, processo ou sistema através do trabalho participativo desenvolvido por uma equipe de alunos, levando-os a coletarem dados e informações (fatos), a gerarem ideias e a identificarem suas necessidades de aprendizagem, num processo onde à busca das respostas (supervisionada pelos professores) lhes possibilitam encontrar na teoria das disciplinas de apoio ao projeto soluções para a concretização do objetivo proposto, como resultado final (Tavares, De Campos & De Campos, 2014). Essa abordagem pode ser utilizada no desenvolvimento de projetos em um contexto profissional real, no qual equipes de estudantes resolvem um problema interdisciplinar, articulando teoria e prática durante o desenvolvimento do projeto (Lima et al., 2017b).

A abordagem Project Based Learning (PBL) foi a metodologia ativa escolhida para ser aplicada no curso de Engenharia de Produção da Escola de Engenharia de Petrópolis da UFF e que também é utilizada nos cursos de Engenharia de Produção da USP e da UnB.

2.2 Manutenção de turbinas aeronáuticas

A evolução dos sistemas de manutenção pode ser dividida em cinco fases: corretiva, preventiva, lean, green e sustentável (Jasiulewicz-Kaczmarek, 2013).

Enquanto o sistema de manutenção corretiva tem como objetivo apenas corrigir ou restaurar as condições de funcionamento do equipamento ou sistema (Pinto & Xavier, 2001). O sistema de manutenção preventiva vai um pouco mais além e tem como objetivo reduzir ou evitar a avaria do equipamento, utilizando um plano antecipado de manutenção, com intervalos de tempo definidos, e com cuidados preventivos para evitar as falhas (Kardec et al., 2003).

Por sua vez, o sistema de manutenção lean pode ser definido como um sistema proativo que utiliza atividades planejadas e programadas e que é fundamentado nos princípios da Manutenção Produtiva Total (TPM). Esse sistema tem como objetivos a gestão da carga de trabalho, a redução do tempo de parada dos equipamentos, a garantia da eficácia do trabalho, a aplicação de práticas que otimizem e garantam a confiabilidade dos equipamentos (Shah & Ward, 2007).

Considerando que as atividades de manutenção não podem lidar apenas com avarias, falhas e conservação de máquinas e dispositivos, o sistema de manutenção green realiza as atividades que devem manter ou restaurar o equipamento ao seu estado requerido, levando em conta a maior eficiência no uso de recursos e menor poluição ambiental (Jasiulewicz-Kaczmarek, 2013). Já o sistema de manutenção sustentável além de considerar todas as fases do ciclo de vida do produto, inclui e antecipa mudanças nas tendências sociais, ambientais, econômicas e os benefícios de tecnologias inovadoras. Esse sistema tem como objetivo aumentar a rentabilidade e otimizar o custo total do ciclo de vida sem deixar de considerar as questões sociais e ambientais (Jasiulewicz-Kaczmarek, 2013).

Devido a sua complexidade, um sistema de manutenção de turbinas aeronáuticas deve buscar ser proativo e utilizar procedimentos relacionados aos conceitos de manutenção lean, green e sustentável. Esse tipo de sistema utiliza um conjunto de processos que requerem procedimentos específicos para a identificação e reparo nas diversas estruturas de uma turbina aeronáutica, buscando assegurar que os componentes e equipamentos mantenham os seus níveis iniciais de segurança e confiabilidade (Jasiulewicz-Kaczmarek, 2014).

A abordagem PBL foi aplicada em uma organização que realiza serviços de manutenção, assistência técnica e revisão de turbinas aeronáuticas. Esse serviços de manutenção são complexos, com grandes reparações, revisões gerais e modificações. As organizações que prestam esse tipo de serviço dependem fortemente do atendimento às demandas dos clientes em qualidade e prazos de entrega reduzidos (Ayeni et al., 2011). Esse estudo apresenta o trabalho realizado por grupos de alunos na otimização do fluxo de peças em uma organização que realiza a manutenção profunda de turbinas aeronáuticas.

3 Metodologia

Esse estudo integra uma pesquisa mais abrangente, chamada aqui de pesquisa maior, cuja a questão central é: *Como aplicar a abordagem Project Based Learning (PBL) em um curso de graduação de engenharia de produção?* (Figueiredo, Guimarães & Ignacio, 2016) O objetivo do estudo é aplicar o modelo inicial da abordagem PBL em Engenharia de Produção, proposto pela pesquisa maior, nas disciplinas do grupo de conteúdos Síntese e Integração que compõe a espinha dorsal e linha condutora da formação em Engenharia de Produção do primeiro curso de graduação da Escola de Engenharia de Petrópolis da Universidade Federal Fluminense. O grupo Síntese e Integração é o principal responsável pela aprendizagem dos conteúdos relativos ao projeto, execução, controle, melhoria e inovação de sistemas de produção e engloba aspectos de síntese, integração e empreendedorismo (UFF, 2014).

A aplicação da abordagem PBL foi realizada na disciplina Projeto de Sistema de Produção I (PSP I) que tem como objetivo capacitar o aluno a desenvolver competências e habilidades: relativas a realização de projeto em grupo; a utilização de técnicas de comunicação e expressão; e a aplicação de métodos, técnicas e procedimentos da metodologia científica em engenharia de produção. A disciplina PSP I é vinculada ao laboratório temático do Departamento de Engenharia de Produção, responsável pelas atividades de ensino, pesquisa e extensão relacionadas ao projeto, implantação, operação, avaliação e melhoria de sistemas de produção.

No âmbito de um estudo de caso na empresa Avio do Brasil, controlada pela GE Celma e, ambas pertencentes à General Electric Aviation, primeiramente foi formulada a seguinte situação problema: "*Como otimizar o fluxo de peças no processo de manutenção da turbina aeronáutica GE J85-21C, de forma a assegurar o cumprimento do prazo estipulado em contrato com a FAB?*". Em seguida, os alunos planejaram e executaram três projetos para ajudar a solucionar a situação problema proposta pela empresa.

Nos próximos subitens é apresentada a classificação da pesquisa; a unidade de análise; os procedimentos para coleta e análise dos dados; a descrição das etapas de planejamento, execução e avaliação dos projetos para aplicação da abordagem PBL.

3.1 Classificação da pesquisa

Não existem um consenso sobre a tipologia das pesquisas e que podem ser classificadas segundo diferentes maneiras. Na engenharia de produção a classificação que normalmente se utiliza é com relação ao escopo da pesquisa, considerando também o tipo de abordagem de pesquisa (Cauchick, 2012). No caso desse estudo, ele pode ser classificado como de natureza exploratória, utilizando a abordagem de estudo de caso e com base em dados e métodos de natureza qualitativa. A abordagem de estudo de caso foi escolhida porque a pesquisa é de natureza empírica que investiga um fenômeno contemporâneo, dentro de um contexto real de vida, onde as fronteiras entre o fenômeno e o contexto em que ele se insere não são claramente definidas (Cauchick, 2012; Yin, 2001).

3.2 Unidade de análise

A unidade de análise da pesquisa foi a empresa Avio do Brasil, controlada pela GE Celma e, ambas pertencentes à General Electric Aviation. A empresa é especializada em atividades de manutenção, assistência técnica e revisão de motores aeronáuticos e é responsável pela revisão dos motores dos caças operados pela Força Aérea Brasileira.

3.3 Procedimentos de coleta de dados

Na pesquisa de campo foram utilizadas três fontes de dados: entrevistas, documentos e observação direta, visando não fixar a análise em apenas uma fonte, conforme recomenda Yin (2001).

Para as entrevistas foi utilizada a técnica de amostragem por conveniência. Os engenheiros da empresa que atuaram como facilitadores indicaram os colaboradores a serem entrevistados em função do envolvimento e conhecimento que tinham da situação problema. As entrevistas semiestruturadas foram realizadas com os colaboradores envolvidos diretamente com o processo de manutenção da turbina.

A análise documental foi realizada com base em documentos disponibilizados pela empresa e ajudou na contextualização do caso.

A observação direta foi utilizada para coletar informações durante as reuniões e visitas técnicas realizadas na empresa. As informações obtidas com a observação foram armazenadas em diários de campo, utilizados para relatar as observações e percepções dos membros dos grupos sobre as reuniões e visitas técnicas realizadas.

3.4 Procedimentos de avaliação e análise dos dados

As informações coletadas nas entrevistas, anotadas no diário de campo e constantes nos documentos consultados foram analisadas conjuntamente e consolidadas em relatórios. Com essa forma triangulada de análise dos dados garantiu-se a confiabilidade e a validade do estudo de caso.

3.5 Etapas da aplicação da abordagem PBL

A abordagem PBL foi aplicada, utilizando as boas práticas de gestão de projetos preconizadas pelo PMBOK (PMI, 2013) e seguindo as cinco etapas descritas a seguir.

3.5.1 1ª. Etapa – Definição da situação problema e elaboração do termo de abertura do projeto

Primeiramente, o professor responsável pela disciplina PSP I fez uma apresentação para a direção da empresa sobre a abordagem PBL e sobre a proposta de aplicação. Em seguida, discutiu a proposta com a equipe da empresa e acordou como a abordagem seria aplicada. Nessas reuniões foi acordado: que os grupos de alunos fariam semanalmente uma visita técnica a empresa para coletar as informações necessárias; que a empresa designaria três engenheiros para atuarem como facilitadores do trabalho; as regras de conduta dos alunos em relação as normas de segurança do trabalho, meio ambiente e saúde; e os mecanismos de controle durante a permanência dos alunos nas instalações da empresa.

A empresa definiu para os três grupos de alunos a mesma situação problema e cada grupo focou seu estudo em um determinado subprocesso de manutenção da turbina. O grupo 1 focou no subprocesso de desmontagem do motor, o grupo 2 no subprocesso de manutenção dos acessórios e o grupo 3 no subprocesso de reparos.

Baseado na situação problema, cada grupo elaborou e apresentou o termo de abertura do projeto para o professor responsável pela disciplina e para a equipe da empresa. As informações inseridas no termo de abertura foram: a justificativa, objetivo e benefícios do projeto; o produto a ser entregue; as partes interessadas e o cronograma geral inicial.

3.5.2 2ª. Etapa – Elaboração do plano de gerenciamento do projeto

Primeiro, os grupos definiram o escopo do produto e do projeto e consolidaram esse escopo na Estrutura Analítica do Projeto (EAP). Segundo, os grupos definiram as atividades a serem realizadas para os pacotes de trabalho constantes na EAP. Terceiro, os grupos identificaram e avaliaram os riscos e definiram atividades para prevenir e/ou mitigar os riscos identificados. Por fim, os grupos definiram os procedimentos de comunicação com as partes interessadas e os procedimentos gerais de gerenciamento do projeto.

3.5.3 3ª. Etapa – Execução e controle do projeto

Os três projetos foram executados, utilizando como mecanismos de controle as EAPs e os cronogramas dos projetos. Semanalmente as equipes reuniam-se com o professor da disciplina na universidade e com os facilitadores na empresa.

3.5.4 4ª. Etapa – Encerramento do projeto

Os grupos apresentaram publicamente seus projetos, entregaram aos representantes das empresas os produtos desenvolvidos e ao professor responsável pela disciplina o relatório final do projeto.

3.5.5 5ª. Etapa – Avaliação dos alunos

A avaliação do desempenho dos alunos foi realizada considerando aspectos relativos ao trabalho em grupo e individual.

A avaliação do trabalho em grupo foi realizada em função da satisfação da empresa com o produto desenvolvido e das principais entregas dos projetos: situação problema e termo de abertura; plano de gerenciamento do projeto, o produto entregue e o relatório final do projeto.

A avaliação individual foi realizada com a aplicação de um questionário, contendo um conjunto de afirmativas relativas as atitudes desejáveis dos alunos na realização de um projeto, utilizando a abordagem PBL. Os alunos avaliaram a si mesmos e seus pares e o professor avaliou os alunos individualmente.

4 Resultados

Nesse item são apresentadas as análises realizadas e as propostas de melhoria dos três grupos para otimizar o fluxo de peças nos subprocessos de desmontagem do motor, manutenção dos acessórios e reparo de peças.

4.1 Análise e propostas de melhorias para o subprocesso de desmontagem do motor

O grupo 1 focou seu trabalho na identificação das peças prioritárias e na otimização dos procedimentos de desmontagem dessas peças.

Primeiramente, as peças prioritárias foram identificadas em reuniões realizadas com os engenheiros da empresa, utilizando como critérios a ordem de montagem do motor, dados históricos e o tempo necessário para o reparo das peças. As vinte e cinco peças priorizadas foram agrupadas e colocadas em diferentes carrinhos e em uma sequência ótima de desmontagem. As peças priorizadas foram fotografadas para facilitar a visualização pelos colaboradores. Em seguida, para otimizar os procedimentos das peças priorizadas, foi realizado o fluxograma detalhado de desmontagem das peças críticas e coletado o tempo de execução. As informações para elaboração dos fluxogramas e os tempos de execução foram coletados em entrevistas com os colaboradores e em documentos fornecidos pela empresa.

Baseado nas informações coletadas, o grupo 1 identificou e propôs as seguintes oportunidades de melhoria: modificação do processo de triagem e desmontagem; designação de um único colaborador para registrar na ordem de serviço todas as atividades de manutenção relacionadas a peça a ser manutenida; os mecânicos desmontarem primeiramente os módulos mais complexos; utilização de compartimento de *vanes* e *blades*; utilização de procedimentos padrão de desmontagem das peças prioritárias, com instruções que tornem a desmontagem mais rápida; utilização de formulário padrão de limpeza das peças prioritárias; livro de fotos das peças críticas; proposta de procedimentos específicos para agilizar a limpeza do *combustion liner*; e sequenciamento de processos com mais de um motor.

4.2 Análise e propostas de melhorias para o subprocesso de manutenção dos acessórios

O grupo 2 focou seu trabalho na priorização dos acessórios críticos. Para entender o fluxo de peças na manutenção dos acessórios, primeiro foi realizado o mapeamento do processo em três níveis: SIPOC, fluxograma detalhado e tarefas. Com o mapeamento foi possível ter uma visão mais ampla e detalhada do processo e identificar as atividades mais críticas. Em seguida, foram percorridos todos os caminhos possíveis dos acessórios durante sua manutenção. Esses caminhos foram obtidos em uma série de visitas ao chão de fábrica, acompanhadas pelo engenheiro facilitador. Nessas visitas, os mecânicos envolvidos com a manutenção dos acessórios foram entrevistados sobre qual seria a ordem de manutenção dos acessórios preferida por eles. Por fim, foi realizada a análise da planilha de tempo padrão de manutenção dos acessórios com o objetivo de identificar e priorizar os critérios de avaliação a serem utilizados na sequência otimizada de manutenção dos acessórios. As ferramentas utilizadas nessa análise foram o diagrama de causa e efeito e o método Analytic Hierarchy Process (AHP). Com a análise foi possível agrupar os quarenta e um acessórios da turbina J85 em três grupos, em ordem de maior complexidade e horas trabalhadas e apontar possíveis oportunidades de melhoria no fluxo e no layout das oficinas.

Baseado nas informações coletadas, o grupo 2 identificou e propôs as seguintes oportunidades de melhoria: realizar a checagem de PN e SN somente na etapa de Triagem, evitando o retrabalho; definir o nível de serviço do acessório antes mesmo da Inspeção Preliminar, pois as Fichas Históricas viabilizam a determinação do workscope antes do acessório ser removido e passar pela a etapa de Triagem; realizar a manutenção dos acessórios por grupos de prioridade e na sequência otimizada proposta pelo grupo; e utilizar uma estante exclusiva para peças de acessórios que permita a priorização dos serviços nos acessórios.

4.3 Análise e propostas de melhorias para o subprocesso de reparo

O grupo 3 focou seu trabalho no subprocesso de reparo de peças da turbina que é um dos subprocessos mais críticos, pois tem um grande impacto no tempo de entrega do motor reparado.

Nas primeiras reuniões realizadas com o diretor da empresa e o engenheiro que atuava como facilitador dos trabalhos do grupo, foi identificada a necessidade de definir o tempo padrão das atividades de reparo das peças. Devido a grande quantidade de peças possíveis de serem reparadas, o trabalho do grupo focou em vinte peças, consideradas críticas devido ao tempo necessário para reparo, frequência de necessidade de reparo e complexidade das operações a serem executadas. Em seguida, o grupo elaborou uma matriz contendo o tempo padrão médio de reparo das peças críticas que tiveram reparos executados no mínimo uma vez nos últimos dez motores manutenidos e que não necessitaram de serviços fora da empresa.

Baseado na análise dos dados da matriz de tempo padrão médio, o grupo identificou e propôs as seguintes oportunidades de melhoria: estimativa mínima do número de peças indispensáveis no estoque; adoção de centro de trabalho ao invés de centro de custo, detalhando os tipos de reparos realizados durante uma ordem de produção específica e melhorando a gestão do tempo de execução das atividades; utilização de estantes exclusivas para peças críticas; e sequenciamento otimizado das peças críticas a serem enviadas para o setor de reparo.

5 Conclusão

Este trabalho apresentou a aplicação da abordagem PBL numa das disciplinas do conteúdo Síntese e Integração que compõe a espinha dorsal e linha condutora da formação em Engenharia de Produção do curso da UFF em Petrópolis.

Os três grupos de alunos conseguiram apresentar soluções para situação problema proposta pela empresa. As oportunidades de melhoria propostas estão sendo implantadas e a direção da empresa ficou satisfeita com o trabalho realizado. A parceria na realização dos PBL está tendo continuidade com a realização de mais dois projetos com alunos.

Para solucionar a situação problema, os alunos tiveram que estudar por conta própria sobre manutenção de turbinas aeronáuticas, mapeamento de processos, ferramentas da qualidade e de pesquisa operacional.

Os alunos também tiveram a oportunidade de conviver semanalmente, durante todo o semestre com a direção, a equipe de engenheiros e mecânicos da empresa. Esse convívio semanal estimulou os alunos a internalizarem diversos aspectos da cultura organizacional da empresa, principalmente as suas práticas de excelência relativas a sustentabilidade, qualidade, segurança do trabalho e ergonomia.

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University class: what space-time is this in Engineering teaching of the XXI century?

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Abstract

Contemporary society, based on a symbiotic relationship with the Information and Communication Technologies, is undergoing an accelerated state of changes that have had a significant impact on our way of being, living, reading, and interacting with the world around us. This ongoing process of change, combined with political and economic choices that promote the standardization and commodification of education and have produced regulation and restriction processes in teaching practices, requires one to rethink formal education at different levels, especially in the teaching and learning processes carried out by educational institutions. Given this scenario, and focusing on higher education, this research aims to understand new meanings for college classes. Based on theoretical studies guided in the new relations of teachers with teaching knowledge and on data obtained in a pedagogical research-action conducted with students from three evening engineering courses at a Brazilian non-state higher education institution, it presents arguments that the class can be more than a formality required to obtain a college degree - it can be a space and a time where students and professors, in addition to learning contents, are mobilized to learn to read the world critically; a training space for emancipated citizens able to interact with and transform the society in which they live; a human formation space compatible with the requirements imposed by the 21st century. The theoretical foundations of this work are guided, among others, in the critical pedagogy of Freire and in the works on action research of Franco. In the area of Engineering, it is based on a Goldberg, Galloway and Crawley et al.

Keywords: Higher education. University class. Engineering Education. Active Learning.

Aula universitária: que espaço-tempo é esse no ensino de Engenharia do século XXI?

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Abstract

A partir de uma relação simbiótica com as Tecnologias da Informação e Comunicação, a sociedade contemporânea encontra-se em um estado acelerado de mudanças que impactam significativamente nossa forma de ser, de estar, de ler e interagir com o mundo à nossa volta. Esse processo continuado de mudança, aliado a opções político-econômicas que promovem a padronização e mercantilização do ensino, e que têm produzido processos de regulação e cerceamento nas práticas docentes, exige um repensar sobre a Educação formal em seus diferentes níveis, principalmente nos processos de ensino e aprendizagem conduzidos pelas instituições de ensino. Diante desse cenário, e focando o Ensino Superior de Engenharia, esta investigação pretende compreender novos sentidos para a aula universitária. A partir de estudos teóricos pautados nas novas relações dos docentes com o saber docente, e de dados obtidos em uma pesquisa-ação de cunho pedagógico realizada com alunos de três cursos noturnos de Engenharia de uma instituição brasileira de ensino superior não estatal, apresenta argumentos de que a aula pode ser mais que um formalismo necessário para obtenção de um título universitário - ela pode ser um espaço e um tempo onde alunos e professores, além de aprender conteúdos, sejam mobilizados para aprender a ler o mundo de forma crítica; um espaço de formação de cidadãos emancipados aptos para interagirem e transformarem esta sociedade na qual estão inseridos, uma formação compatível com as exigências da sociedade do século XXI, bem como com as exigências da formação de profissionais engenheiros críticos e preparados para os desafios atuais e futuros Os fundamentos teóricos deste trabalho pautam-se, entre outros, na área da Educação, na pedagogia crítica de Freire e nos trabalhos sobre pesquisa-ação de Franco. Na área das Engenharias, fundamenta-se em Goldberg, Galloway e Crawley et al.

Keywords: Ensino superior. Aula universitária. Educação em Engenharia. Metodologias Ativas.

1 Introdução

A partir de meados do século XX, as inovações tecnológicas que ocorrem principalmente nas áreas da microeletrônica e automação passam a ser amplamente utilizadas nos processos produtivos ao mesmo tempo em que o capital financeiro vai ganhando destaque no cenário econômico. Em consequência, vê-se o nascimento de um novo paradigma social, uma sociedade pós-industrial que se ancora fortemente na informação. A esse novo paradigma, que pode ser considerado uma nova ideologia, atribuem-se, indistintamente, entre outras, as expressões "Sociedade da Informação" ou "Sociedade do Conhecimento" (Masson & Mainardes, 2011). Nele, pode-se observar uma relação simbiótica entre informação, um de seus pilares, e um sistema que integra, através de caminhos convergentes de desenvolvimento, diferentes ramos tecnológicos. Resultam daí as tecnologias de informação e comunicação (TIC) que permitem processos reversíveis, que facilitam a reorganização e a reconfiguração de componentes, e incluem a flexibilidade como uma das características desse novo paradigma (Werthein, 2000). Essa flexibilidade tem permitido, de forma eficiente, a concretização de processos de "[...] desregulamentação, privatização e ruptura do modelo de contrato social entre capital e trabalho característicos do capitalismo industrial" (Werthein, 2000, p. 72).

Esse cenário de flexibilidade aliado às próprias características do conhecimento contemporâneo que, segundo Bernheim e Chaui (2008) cresce, torna-se complexo e tende a ficar obsoleto de forma cada vez mais rápida, requer um "[...] trabalhador polivalente e versátil, proativo no processo de trabalho, com envolvimento físico, emocional e cognitivo no desempenho de suas funções laborais" (Guimarães, Monte & Farias, 2013, p. 40), um trabalhador integrado a um processo contínuo de formação, de elaboração de seu próprio conhecimento.

O documento Knowledge Management in the Learning Society (OECD, 2000) classifica o conhecimento em quatro categorias. A primeira inclui o conhecimento sobre fatos (Know-what), ou seja, conhecimentos que se aproximam do conceito de informação. A segunda inclui o conhecimento gerado a partir do trabalho científico (Know-why), fundamental para o desenvolvimento tecnológico em áreas que possuem a ciência como base. A terceira engloba o conhecimento individual ou de um grupo (Know-how), relacionado com a habilidade de realizar tarefas – envolve a noção de prática, experiência baseada na aprendizagem, e outras habilidades pessoais como, por exemplo, a intuição. Apesar de o Know-Why ser fundamental, o Know-how, embora mais restrito dependente de habilidades pessoais, pode ser comercializado, e tem ganhado importância no mercado de trabalho. A quarta categoria considera o conhecimento reunido a partir da interação/cooperação com diferentes pessoas e/ou especialidades (Know-who). Em uma época em que se vê convergências de tecnologias e que a interdisciplinaridade ganha destaque, a importância desse tipo de conhecimento cresce a cada dia. É em busca desse conhecimento que muitas empresas se envolvem com pesquisas acadêmicas conectando seus profissionais com a rede de peritos acadêmicos.

Nesse cenário onde "[...] o diploma não significa mais uma conclusão, mas apenas o reconhecimento de que um estágio se encerra, enquanto outros se iniciam, sem fim". (Demo, 2011, p. 79) é que situamos, como professores, o desafio de formar novos engenheiros aptos a participarem de forma ativa na sociedade; engenheiros com autonomia intelectual não apenas para o aprendizado contínuo de conhecimentos técnicos e científicos, mas também para seu desenvolvimento como cidadão crítico, consciente de sua realidade sócio-econômica_política-cultural, para desenvolver-se como sujeito participante de comunidades formadas a partir de redes de relacionamentos.

O engenheiro do século XXI não é mais aquele que apenas utiliza seus conhecimentos técnicos para resolver problemas, mas aquele que utiliza, além da sua base de fundamentos técnicos, sua capacidade crítica e criativa para resolver problemas considerando o contexto histórico, social, econômico e político em que o problema está envolvido, trabalhando em rede, cooperando em equipe e não mais sozinho: um momento de desafios e oportunidades (Duderstadt, 2010), onde o desenvolvimento tecnológico e do acesso a informação não apenas elevem as condições da humanidade mas também permita a criação de uma nova sociedade pautada no desenvolvimento sustentável, no envolvimento político e na interação e transformação social, sendo o papel do engenheiro fundamental nesse processo (Galloway, 2007 ; Goldberg, 2006).

Milititsky (2007) ajuda a defesa dessa tese sobre o papel do engenheiro na contemporaneidade ao informar que a empresa norte-americana Boeing acredita que o engenheiro formado para exercer a profissão no século XXI deva ter além de uma boa base de fundamentos de ciência da Engenharia em seu perfil, o entendimento de processos e projetos, entendimento do contexto social, econômico e político no qual é praticada a Engenharia, capacidade de comunicação, habilidade de pensar de forma criativa e crítica, de forma independente e cooperativa, flexibilidade, habilidade e autoconfiança para adaptação a mudanças grandes e rápidas, curiosidade e vontade de aprender por toda a vida e capacidade de trabalhar em equipe.

2 A educação formal como parte da formação do sujeito

Sem desconsiderar a importância e a influência que o processo educativo pelo qual todo indivíduo vive fora dos muros de instituições de ensino, parte-se do pressuposto, com base em Freire (2011), que a educação formal, aquela fornecida por instituições de ensino, em todos os níveis, apesar de não exclusiva, continua sendo fundamental para a formação de cidadãos críticos, aptos a interagir e transformar seu contexto sócio-político-econômico-cultural. A educação informal, geralmente obtida sem um rigor metodológico, baseada em fórmulas prontas, na curiosidade ingênua, sem criticidade, está sujeita à ideologia vigente.

A ideologia, como explica Freire (2011), é ardilosa, tem o poder de restringir nossa leitura do mundo mostrando-nos uma realidade distorcida, pode minimizar nosso poder de um agir crítico. A educação formal, quando feita a partir de uma prática educativa que incentive a criatividade, o questionar, o refletir sobre as questões que formula, o olhar crítico sobre as informações acessadas, a ousadia de descontruir e reconstruir, enfim, o aprender a aprender a partir de um rigor metódico que transforma a "curiosidade espontânea" em uma curiosidade "epistemológica", contribui "[...] tanto no esforço de reprodução da ideologia dominante quanto no seu desmascaramento" (Freire, 2011, p. 96). A educação, "[...] enquanto reflexo, retrata e reproduz a sociedade; mas também projeta a sociedade que se quer" (Pimenta & Anastasiou, 2002, p. 97).

O treinamento ou capacitação técnica, por sua vez, embora útil e necessário, não pode ser, conforme Demo (2011), a base do processo educativo de cidadãos para a sociedade atual, que exige "[...] soberbo pensar, capacidade constante de inovação, principalmente de renovação profissional, aprendizagem permanente, manejo virtuoso do conhecimento" (Demo, 2008, p. 37).

Assim considerando, o ensino superior contemporâneo, nível de ensino formal onde se localiza os cursos de Engenharia, deve desenvolver nos alunos as seguintes competências básicas:

> capacidade reflexiva e crítica; capacidade de solução de problemas; capacidade de adaptação a novas situações; capacidade de selecionar a informação relevante nas áreas de trabalho, cultura e exercício da cidadania, que lhe permite tomar decisões corretas; capacidade de continuar aprendendo em contextos de mudança tecnológica e sociocultural acelerada, com a permanente expansão do conhecimento; capacidade de buscar espaços intermediários de conexão entre os conteúdos das várias disciplinas, de modo a realizar projetos que envolvam a aplicação de conhecimentos ou procedimentos próprios de diversas matérias; capacidade de apreciar a leitura e a escrita, o exercício do pensamento e a atividade intelectual, de modo geral (Bernheim & Chaui, 2008, p. 34).

Considerando ainda, conforme Araújo (2012), que a aula continua sendo o elemento central do processo de ensino-aprendizagem, este trabalho a adota como objetivo de estudo para compreender seu lugar no ensino de engenharia no século XXI e, de forma mais geral, no ensino superior de graduação.

3 A aula universitária

Tradicionalmente, a aula tem sido entendida a partir de uma perspectiva muito particular: um evento que acontece em um espaço físico específico, em certo horário, destinado à transmissão de informações para um certo grupo de alunos.

Esse conceito de aula como um espaço e um tempo para transmitir conhecimento, aqui denominado "aula reprodutiva", continua sendo, segundo Demo (2008) praticado no ensino superior, onde o que a maioria dos professores faz é dar aulas, repassando aos alunos informações que poderiam ser obtidas em outros locais; e os alunos comparecem às aulas porque são obrigados e, ao provarem que sabem reproduzir o conhecimento transmitido recebem, como prêmio, o diploma.

Nele, os alunos continuam sendo vistos como sujeitos passivos, que recebem informações de forma estruturada, a partir de sequências organizadas e transmitidas pelos professores. (Pedroso, 2007).

Freire (2011, 2012) não cita diretamente o ensino superior, nem o evento aula, mas também critica a relação entre educador e educandos baseada, predominantemente, na narração, que inibe o poder de criar, de transformar. Nesse modelo, denominando pelo autor como "educação bancária", os alunos são considerados "vasilhas" nas quais se depositam conteúdos representativos de recortes da realidade, que dificilmente ganham significado, porque são desconectados de uma visão da totalidade. O professor é o agente ativo, aquele que sabe e doa o seu saber, aquele que pensa, que opta, que escolhe o conteúdo, que educa, que impõe a disciplina. O aluno, o ser passivo que recebe e se molda, adapta-se, domestica-se como expectador, não como um agente transformador ou recriador desse mundo.

Entretanto, considerando a aula como sendo "[...] o locus produtivo da aprendizagem [...]" (Veiga, Resende & Fonseca, 2002, p.175), ela não pode ser concebida simplesmente como um espaço e um tempo no qual se transmite informações. Nesse sentido, Silva (2012) apresenta um conceito ampliado de aula, ao conceituá-la como espaço/tempo de formação humana.

Considerar a aula como um espaço/tempo de formação humana significa voltar o olhar para realidades social, cultural, científica e tecnológica das quais ela, a aula, não pode estar desconexa. Significa organizá-la a partir de uma

> [...] intencionalidade do trabalho pedagógico [que oriente] a forma como são selecionados os objetivos educativos, os conteúdos, os métodos, o processo de avaliação, como a relação professor-aluno é

> conduzida e a compreensão de que essas opções teórico-metodológicas não se caracterizam pela neutralidade, ao contrário, expressam concepções de sociedade, educação e homem. (Silva, 2012, p.38).

Assim conceituada, a "aula" sintoniza-se com o conceito de educação proposto por Freire (2011, 2012), que é baseado no diálogo verdadeiro, fundamentado por um pensar crítico, um escutar paciente, mediado pelo mundo e que não se limita à relação eu-tu. Para que haja esse diálogo verdadeiro, é preciso humildade; é preciso reconhecer que a ignorância não está apenas no outro e, portanto, a contribuição do outro é benéfica; é preciso um pensar crítico (Freire, 2012); é preciso escutar o outro. "Somente quem escuta pacientemente e criticamente o outro, fala com ele, mesmo que, em certas condições, precise falar a ele". (Freire, 2011, p. 111).

Para que haja o diálogo, o professor não pode colocar-se no papel do senhor absoluto, inflexível, aquele que vê os alunos como submissos à sua forma de pensar e agir. Por outro lado, não pode alimentar ou permitir o descompromisso, o desrespeito. Ambas as posturas são prejudiciais ao processo de aprendizagem. A autoridade do professor, no sentido de liderança, de responsabilidade, é proveniente da aceitação legítima que só pode ser obtida a partir do respeito pelos alunos.

Essa autoridade não pode ser eliminada ou desprezada – é preciso ser cultivada, é necessária ao ato pedagógico (Nogaro, 2008). Ela, entretanto, não se traduz em uma relação hierárquica vertical, que o coloca em um nível superior àquele ocupado pelos alunos, mas contribui para dar ao professor um papel singular, diferente daquele exercido pelos alunos. Isso não significa que eles devem ser independentes ou que não haja responsabilidades bem definidas. A autonomia e a liberdade do professor e dos alunos nascem da relação de reciprocidade estabelecida entre eles, e estão sempre articuladas com a responsabilidade. Professor e alunos, juntos, fazem a aula. Isso não significa que o fazem de forma igual – pelo contrário, é na diferença dos papéis, materializados a partir das subjetividades dos sujeitos e do contexto social, no qual estão mergulhados, que o diálogo se estabelece. (Rios, 2012).

> Nesta perspectiva, a didática – como ensinamos o que ensinamos – é um ato responsivo, uma resposta responsável e não indiferente ao outro – sujeitos a quem o ensino se dirige. Mas, como o campo da didática é multidimensional, as respostas também são multidirecionadas. São muitos os outros escutados e respondidos no ato de ensinar e aprender. Ato ético, estético, epistemológico e político no qual a não indiferença é o que move e dá sentido ao passo dado por sujeitos situados, que firmam o seu compromisso com o outro – os vários outros [...] (Corsino, 2015, 401).

Indo ao encontro dessas questões, surgiu no ensino de Engenharia, no final do século XX e início do século XXI, o movimento de adoção de metodologias ativas de aprendizado nas aulas de Engenharia no Brasil e no Mundo, como por exemplo a iniciativa CDIO (Crawley et al., 2007), movimento esse que tem ganhado cada vez mais adeptos e força na Engenharia Nacional, entretanto os métodos tradicionais de aulas expositivas e ensino depositário ainda prevalece.

"Metodologias ativas" é uma expressão que está sendo bastante utilizada sem, no entanto, uma conceituação clara. Muitas vezes, é utilizada simplesmente como contraponto ao conceito incorreto de "aprendizagem passiva". A aprendizagem, nunca é passiva - ela sempre gera algum tipo de mudança (Drew & Mackie, 2011). Outros associam a expressão para referenciar métodos já estabelecidos e divulgados: Peer Instruction ou educação pelos pares; Aprendizagem Baseada em Problemas, Team Based Learning ou Aprendizagem Baseada em Equipes, Flipped Classroom ou Sala de Aula Invertida etc.

De maneira objetiva, as metodologias ativas de aprendizagem fazem parte de práticas pedagógicas que têm como requisito principal o envolvimento dos alunos em atividades que proporcionem aprendizagem significativa, e que contribuam para o desenvolvimento do pensamento crítico (Freeman, 2014; Prince, 2004). São práticas que se pautam, entre outras, na interatividade, em estudos e pesquisas individuais e em grupo, que são conduzidas pelo professor (Bastos, 2006). Não excluem trabalhos extraclasse ou outros elementos que estão presentes nos métodos tradicionais de aula, mas pressupõe que tais atividades também podem ser desenvolvidas no *espaçotempo* da sala de aula. Pautam-se no engajamento e protagonismo do estudante no processo de aprendizagem, contrastando assim com as aulas tradicionais focadas na transmissão do conteúdo e na passividade do aluno (Prince, 2004).

Assim conceituadas, metodologias ativas estão situadas em uma epistemologia de educação que não se limita ao puro tecnicismo, à simples aplicação de uma técnica ou um método em sala de aula.

> Para que as Metodologias Ativas possam causar um efeito na direção da intencionalidade pela qual são definidas ou eleitas, será necessário que os participantes do processo as assimilem, no sentido de compreendê-las, acreditem em seu potencial pedagógico e incluam uma boa dose de disponibilidade intelectual e afetiva (valorização) para trabalharem conforme a proposta, já que são muitas as condições do próprio professor, dos alunos e do cotidiano escolar que podem dificultar ou mesmo impedir esse intento. (Berbel, 2011, p. 37)

Diante desses desafios, quais as possibilidades pedagógicas da aula assim concebida no atual contexto brasileiro do ensino superior de Engenharia ou, de forma mais geral, no ensino superior de graduação? Essa foi a questão que deu origem a uma pesquisa-ação de cunho pedagógico, abaixo descrita

4 Aspectos da pesquisa realizada

A pesquisa, com abordagem qualitativa, foi realizada em uma instituição de ensino superior (IES) privada, com alunos de três cursos noturnos de engenharia, nas aulas do componente curricular "Gestão de Projetos", com carga horária de 68 horas-aula, o que significou 64 horas-aula de pesquisa com cada uma das três turmas de alunos, resultando em 204 horas-aula de convivência do pesquisador com os sujeitos da pesquisa. Foi desenvolvida em três etapas, durante o período regular de aulas, ou seja, utilizou a mesma infraestrutura, o mesmo horário de aulas, e os mesmos períodos previstos para estar em sala de aula que seriam utilizados por esse componente curricular, caso a pesquisa não fosse realizada.

Conforme orientações de Franco (2005) a respeito de pesquisa-ação, na 1ª. etapa foi feito um diagnóstico inicial objetivando: a) promover um aquecimento coletivo; b) conhecer as percepções individuais dos alunos sobre as aulas que tiveram, até então, no curso de Engenharia em que estavam matriculados; b) promover uma reflexão individual sobre as aulas que tiveram durante o curso, criando assim um cenário adequado para discutir o método de aulas que seria proposto em seguida; d) verificar as expectativas dos alunos a respeito de aulas; e) colher sugestões individuais para melhor planejar os próximos passos da pesquisa.

A realização do diagnóstico foi feita através de um questionário contendo 5 questões abertas,[2] aplicado durante a primeira aula do semestre, após as apresentações habituais, sem uma discussão prévia dos conceitos presentes nas questões formuladas como, por exemplo, "tipo de aula", "aula produtiva" ou "boa aula". Com isso, procurou-se obter respostas provenientes do senso comum dos alunos, sem eventuais influências dos conceitos teóricos que embasaram a pesquisa. Tomou-se o cuidado de esclarecer que ele fazia parte de uma pesquisa e que seu preenchimento era opcional. Mesmo assim, todos os 35 alunos presentes o preencheram e entregaram, o que evidenciou, pelo menos nesse primeiro momento, a receptividade e o espírito de colaboração dos estudantes. Esse processo aconteceu um período de 20 minutos, ou seja, 20% do tempo da aula, mostrando assim a importância dada para a reflexão pretendida. Em seguida, foi apresentada proposta de adotar métodos de aulas que não tivessem características de aulas reprodutivas, esclarecendo que isso exigiria um esforço maior por parte de todos, mas que, teoricamente, resultaria em um melhor aproveitamento das aulas, tanto a respeito do conteúdo estudado como em relação a outros saberes que poderiam ser desenvolvidos ou percebidos como necessários. Ao final de uma discussão, todos os presentes aceitaram a proposta com a condição de que, no decorrer do período letivo, fosse possível abandoná-la caso se mostrasse inadequada.

A 2ª. etapa, a pesquisa-ação propriamente dita, realizada durante as aulas regulares, organizadas na perspectiva de criar contextos que contribuíssem para a participação ativa dos alunos, para o trabalho em

2 Questões do primeiro questionário: (1 – Qual o tipo de aula que você teve nesta instituição que você mais gostou? Por quê?; 2 – Qual o tipo de aula que você teve nesta instituição que você menos gostou? Por quê?; 3 – Para você, o que é uma aula produtiva?; 4 – Para você, o que é uma aula improdutiva?; 5 – Quais as sugestões para uma boa aula?).

equipe, para a prática da reflexão sobre as ações empreendidas, para a adoção da pesquisa como como instrumento de aprendizagem, e que permitisse ao professor assumir o papel de mediador e não de condutor.

Seguindo essas orientações, as aulas[3] foram planejadas com a seguinte estrutura básica: a) explicação inicial dos objetivos da aula e das atividades propostas - sempre que necessário, era incluído, nessa fase inicial, um feedback da reflexão sobre a aula anterior; b) atividades escolhidas de acordo com a complexidade e extensão do conteúdo programático da aula, atividades essas que sempre exigiam a participação ativa dos alunos; c) fechamento da aula, com discussões sobre as atividades realizadas e esclarecimento de eventuais dúvidas - para conteúdos mais complexos, esse espaço era utilizado também para uma síntese da matéria estudada; d) reflexão sobre a aula utilizando um questionário único para todas as aulas[4] – com base na análise das respostas desses questionários, as aulas foram se moldando segundo o feedback obtido dos alunos a respeito da aula anterior. Foram recebidos 1011 questionários, fundamentais para o planejamento das aulas.

A 3ª. etapa aconteceu na última aula com o objetivo de desencadear a reflexão sobre a experiência vivida e colher dados que, juntamente com aqueles obtidos na 1ª. etapa, pudessem contribuir para compreender o significado e as possibilidades pedagógicas da aula no atual cenário brasileiro do ensino superior de Engenharia e, de forma geral no ensino superior de graduação. O questionário com 8 questões abertas[5] foi aplicado no final da última aula e, assim como na primeira etapa, foi enfatizado o fato de que o preenchimento era opcional. Ao todo, foram recebidos 44 questionários preenchidos.

O tratamento dos dados empíricos colhidos durante a primeira e terceira etapas da pesquisa foi feito a partir das técnicas e procedimentos pertencentes à Análise de Conteúdo. Foram considerados dois dos "três polos cronológicos" propostos por Bardin (2000, p. 95) para a organização da análise: a "pré-análise" e a "exploração do material". Esse trabalho, aqui considerado como uma pré-análise, teve como objetivo encontrar categorias que permitissem, juntamente com a fundamentação teórica, melhor compreender o significado e as possibilidades pedagógicas da aula no atual cenário brasileiro do ensino superior de graduação. A análise dos dados, feita após a identificação das categorias de análise, baseou-se na Hermenêutica-dialética, descrita por Mianayo (1999), pois foi o "caminho de pensamento" que se mostrou mais coerente com os objetivos desta pesquisa.

5 Conclusão

A pesquisa apresentou fortes indícios de que os alunos participantes também trazem uma concepção de aula compatível com aquela estabelecida a partir dos teóricos: a aula como espaçotempo de formação humana, baseada na participação ativa de todos os participantes; um espaçotempo em que todos podem aprender; que incentiva o espírito crítico, a pesquisa, a reflexão, o diálogo; a aula que permite ir além do conteúdo nela estudado; que busca um nível mais profundo de aprendizagem. Esses resultados surpreendem porque conflitam com o retrato apresentado em pesquisa realizada por Pimenta e Anastasiou (2002): os alunos são passivos, não demonstram interesse em aprender, não são comprometidos, buscam apenas um diploma etc.

Rué (2009) aponta vários fatores que contribuem para esse comportamento. Entre eles:

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3 Cada aula, com duração de 4 horas-aula, foi considerada um clico da pesquisa-ação.

4 Questões do segundo questionário: (1 – O que você aprendeu nessa aula?; 2 - O que achou desnecessário nessa aula? Justifique; 3 - O que facilitou seu aprendizado nessa aula? Justifique; 4 – O que dificultou seu aprendizado nessa aula? Justifique; 5 – espaço para críticas e/ou sugestões.)

5 Questões do terceiro questionário: (1 - O método adotado nas aulas da disciplina Gestão de Projetos contribuiu para o aprendizado do conteúdo apresentado? Explique; 2 - Além do conteúdo apresentado, o método de aula utilizado trouxe algum outro aprendizado? Explique.; 3 - Quais os fatores que contribuíram para o aprendizado do conteúdo da disciplina Gestão de Projetos? Explique; 4 - Quais os fatores que prejudicaram o aprendizado do conteúdo dado na disciplina Gestão de Projetos? Explique; 5- Em sua opinião, qual foi a finalidade do preenchimento de um questionário no final de cada aula?; 6 - Você trabalha durante o dia? ( ) Sim ( ) Não Quantas horas/dia?; 7 - O que você costuma ler além do material didático indicado pelos professores?; 8 - Pergunta 8: Que sugestões você daria para melhorar o método de aula dessa disciplina?)

- Não há, em geral, coerência entre o volume do conteúdo ensinado com o tempo que os alunos podem disponibilizar para o estudo extraclasse, impossibilitando assim um mergulho mais profundo. Como saída, para obter êxito, procuram explorar apenas a superfície do que lhes é apresentado (Rué, 2009). Esse foi um dos aspectos mais enfatizados pelos participantes da pesquisa, e claramente reconhecido quando se depara com um quadro bastante comum: os alunos de curso noturno em geral trabalham durante o dia, têm aulas todos os dias da semana e, em alguns casos, aos sábados. Resta portanto, para esses alunos apenas parte do final de semana para estudar todos os componentes curriculares do período letivo. Essa é uma questão importante que deve ser considerada pelos professores, repensada pelas instituições de ensino superior e pelos órgãos oficiais responsáveis pela educação superior.
- Nem sempre é feita, por parte do professor, uma contextualização do conteúdo ensinado, dificultando o estabelecimento, por parte dos alunos, de conexões com outros assuntos já estudados. Além disso, em geral, os novos conceitos não são desenvolvidos a partir do conhecimento que o aluno já possui, dificultando a associação do que é ensinado com aquilo que ele, aluno, já aprendeu. O resultado é que o aluno não percebe o valor ou a importância daquilo que está estudando (RUÉ, 2009). Esse também foi um dos pontos enfatizados pelos participantes da pesquisa – para eles, entender o significado do que está sendo estudado, a importância daquele conteúdo para sua formação profissional, o vínculo entre a teoria e a prática são fatores que contribuem para uma aula "produtiva".
- O modelo geralmente utilizado para avaliar o conhecimento baseia-se no enfoque superficial da aprendizagem, ou seja, na memorização de informações. Em função disso, o aluno percebe que, para obter êxito na vida acadêmica, não precisa aprofundar-se naquilo que é ensinado. Outro ponto apontado por Rué (2009) é a pouca contribuição que os processos de avaliação adotados pelos professores oferecem como feedback para que os alunos avaliem seu progresso – em geral, essas avaliações não deixam claros os pontos que os alunos devem rever com mais atenção. Alguns participantes também indicaram problemas no processo de avaliação adotado durante esta pesquisa.

O modelo de aula centrado no professor, com foco na transmissão de informações, também é um dos aspectos apontados por Rué (2009) que colabora com o enfoque superficial de aprendizagem. Para Cunha (2006), esse modelo está incrustrado em nossa cultura e influencia a forma de recrutamento de professores, que se baseia na ideia de que basta saber para saber ensinar, o que, para Zabalza (2004), é um conceito equivocado e não profissional a respeito de educação, pois induz à ideia de que não é preciso se preparar para a docência. Mas não somente a tradição é responsável por reduzir a atividade docente à transmissão de informações. Pimenta e Anastasiou (2002) apontam também as condições do mercado de trabalho na sociedade contemporânea e a grande expansão do segmento de ensino superior como responsáveis pela aceitação de um grande número de profissionais liberais como professores em instituições de ensino superior, sem formação adequada para ensinar. Essas razões, no entanto, justificam que um profissional, ao assumir o exercício do magistério, não procure desenvolver-se ou aperfeiçoar-se em sua profissão? Por que, apesar das transformações sociais e do arsenal teórico existente sobre Pedagogia universitária e processos de ensino-aprendizagem, grande parte dos professores universitários continuam praticando o modelo de aulas reprodutivas? Como as metodologias ativas de aprendizagem podem ajudar nesse processo? Estamos preparados para utilizá-las em nossas Universidades?

Essas e muitas outras questões que poderiam ser formuladas indicam as contradições e complexidade que envolvem o tema "aula universitária" e/ou seu contexto, mas que extrapolam o escopo deste trabalho - questões importantes que ficam como incentivos para novas pesquisas.

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Promovendo a Melhoria do Ensino em Resistência dos Materiais Utilizando Realidade Virtual

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Resumo

O artigo descreve uma metodologia de ensino desenvolvida para promover a aprendizagem em Resistência de Materiais. Essa metodologia tem por base a aprendizagem baseada em problemas (ABP) e utilizou, em sua versão inicial, em 2014, atilhos de borracha e molas para simular esforços de tração, compressão e cisalhamento. Já em 2015, o mesmo projeto foi retomado utilizando um dispositivo háptico, aparelho de pequeno porte, e de baixo custo de implantação, que permite simular os ensaios em realidade virtual (RV). O objetivo desse projeto tem sido inovar e aprimorar a área de educação na engenharia, promovendo um melhor aprendizado dos alunos, além de servir de motivação para que os estudantes possam aprofundar seus estudos nos mais diferentes temas que fazem parte dos currículos de cursos de engenharia. Para avaliar o aprendizado do aluno, faz-se o uso de pré-testes e de pós-testes que visam medir o grau de conhecimento construído. As avaliações são planejadas de forma a avaliar o desempenho do estudante na realização de atividades individuais e em grupo, utilizando o teste estatístico de Wilcoxon.

Palavras-Chave: Educação em Engenharia; Ensino-Aprendizagem; Estratégias Pedagógicas baseadas em Aprendizagem Ativa.

1 Introdução

De acordo com (Loder, 2009), o estudante de engenharia, ao longo de sua trajetória de formação universitária, apresenta uma evolução consubstanciada na construção de conhecimentos, no desenvolvimento de competências técnicas e de atitudes que o levam a desenvolver, paulatinamente, a sua autonomia profissional e moral. Em função desse processo evolutivo, percebe-se que as estratégias pedagógicas utilizadas no ensino devem estar ajustadas às diferentes fases dessa evolução, como pré-condição para o sucesso do uso dessas estratégias no ambiente universitário. Ao acompanhar a trajetória do estudante ao longo de seu processo formativo, verifica-se que, para um mesmo estudante, estratégias pedagógicas idênticas tendem a surtir efeitos diversos no que se refere à aprendizagem do estudante, dependendo do momento em que essas estratégias são aplicadas nas diferentes etapas do curso, isto é, ao longo da trajetória escolar desse estudante.

Na fase inicial do Curso, em que o estudante está envolvido com a sua familiarização ao ambiente universitário, diverso e muito mais amplo do que o ambiente do ensino médio, pré-universitário, uma estratégia pedagógica que priorize um ensino que oriente a ação do estudante, estabelecendo metas bem definidas e resultados mais imediatos, parece ser mais adequada para promover a aprendizagem do estudante. Em estágios mais avançados, quando o estudante já estiver superado, em boa medida, suas dificuldades iniciais de adaptação ao meio universitário e, da mesma forma, estiver superado os obstáculos epistemológicos impostos pela complexidade do campo de conhecimento, uma ação pedagógica que guie e promova, cada vez mais, a autonomia do estudante, parece ser mais eficaz. Já na fase final do ciclo formativo, caracterizado pelo iminente ingresso no mercado de trabalho, quando se espera que o estudante tenha alcançado uma autonomia intelectual e moral plena, o ensino pode se tornar cada vez mais uma orientação de estudos.

A utilização de práticas pedagógicas não condizentes com o estágio de evolução intelectual, moral e afetivo do estudante podem explicar porque algumas ações pedagógicas funcionam bem, em termos de promover a aprendizagem do estudante, no início do curso e nem tão bem ao final do curso e vice-versa, mesmo quando o professor e o aluno analisados são os mesmos. Em geral, a escolha de estratégias de ensino baseadas nos princípios da Aprendizagem Ativa parece contribuir positivamente para a aprendizagem dos estudantes em qualquer nível em que se encontrem do curso de engenharia. Entretanto, garantir a eficácia dessas estratégias requer o monitoramento permanente a fim de identificar o nível de desenvolvimento psicológico, sociológico e intelectual do estudante, caso contrário os esforços e os investimentos necessários para a implantação de estratégias ativas podem ser frustrados em seus objetivos. Para discutir a eficiência de estratégias baseadas em Aprendizagem Ativa, neste Artigo é focalizada uma estratégia pedagógica que privilegia a ação do estudante de engenharia no contexto escolar, no âmbito de um curso de engenharia civil no sul do Brasil, reconhecido pela qualidade de educação de seus graduados.

2 Fundamentação Teórica

A estratégia pedagógica descrita neste Artigo utiliza, como base de sustentação para o seu planejamento e execução, a teoria epistemológica de Piaget. Na teoria piagetiana, o conhecimento é uma construção intelectual cuja gênese é tributária da interação entre sujeito e meio. Assim, o construtivismo piagetiano se contrapõe, simultaneamente, ao empirismo, que nega a ação do sujeito no processo conhecedor, e ao inatismo, que atribui as aprendizagens a qualidades inatas do sujeito. Para PIAGET (1972), *"conhecer não consiste, em copiar o real, mas em agir sobre ele e transformá-lo (na aparência ou na realidade), de maneira a compreendê-lo... "*

A partir da compreensão de que a aprendizagem emerge da ação, motora ou intelectual, e da constatação de que o estudante de engenharia, ao longo de seu curso, evolui em sua autonomia cognitiva e moral, considera-se que as intervenções pedagógicas devem estar ajustadas às diferentes etapas dessa evolução, como uma pré-condição para o sucesso dessas intervenções. Uma vez satisfeita essa pré-condição, as evidências apontam para o fato de que estratégias que priorizem a interação entre professor-aluno e entre aluno-objeto do conhecimento têm mais chances de fomentar a aprendizagem do aluno no âmbito escolar, atendendo, dessa forma, as expectativas tanto do professor quanto de seu aluno.

3 Um exemplo de estratégia pedagógica ativa: Ensino de Resistência dos Materiais utilizando atilhos e interação háptica com Realidade Virtual

Essa proposta surgiu a partir da realização do pós-doutorado de um dos Autores na Faculdade de Engenharia da Universidade do Porto (FEUP), junto ao grupo de pesquisa liderado pela Professora Doutora Teresa Restivo (*Online Experimentation*..., 2015) que desenvolvia, à época, um projeto de pesquisa utilizando interação háptica, com realidade virtual, para determinação da constante elástica de molas (URBAN, CHOUZAL & RESTIVO, 2015; CARNEIRO et al, 2015, 2016; RESTIVO et al, 2014). A partir dessa investigação, o trabalho durante o pós-doutoramento consistiu em ampliar a pesquisa para o estudo do comportamento mecânico de diferentes materiais, tendo como foco a determinação do módulo de elasticidade desses materiais. Em uma primeira etapa, foram utilizados atilhos de borracha, posteriormente, após o desenvolvimento da nova aplicação do háptico, a investigação envolveu um estudo comparativo entre essas duas experiências pedagógicas.

3.1 Descrição da estratégia pedagógica com o uso de atilhos

Inicialmente, promove-se uma etapa de esclarecimento aos estudantes sobre a Lei de Hooke. Nessa etapa, apresenta-se a formulação matemática da Lei e curvas características de alguns materiais. Na sequência, uma atividade prática, a obtenção e a análise dos gráficos obtidos, dando enfoque especial à relação entre a Tensão e a Deformação, caracterizada pelo Módulo de Young (E).

Durante a atividade prática, os alunos trabalham com os conceitos fundamentais da Ciência dos Materiais, tais como a relação força x alongamento e tensão x deformação, evidenciando no experimento prático que o alongamento está diretamente relacionado com a composição do material a partir do Módulo de Young e que a redução da área da secção influencia diretamente no comportamento linear da fase elástica do material. Em cada etapa da atividade, antes, durante e depois da realização dos experimentos, são feitos questionamentos aos alunos. Esses questionamentos são de extrema importância para mensurar o conhecimento construído durante a atividade. Em cada experimento, o próprio aluno mede o comprimento inicial do material, adiciona as massas solicitadas e mede novamente o comprimento, para determinar a deformação do material.

Reesultados da Experiência-piloto realizada

A Figura 1 apresenta uma experiência-piloto realizada com um aluno que já cursou a disciplina de Ciência dos Materiais. Os materiais utilizados foram atilhos com comprimentos de 40 mm e dois valores de área.

Figura 1 – Atividade com atilho

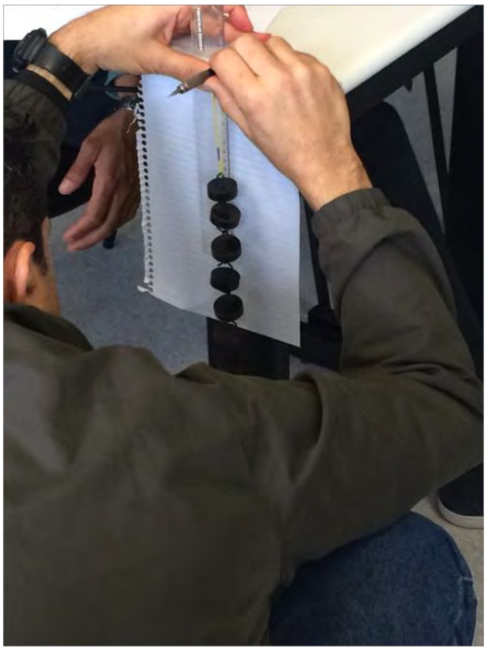
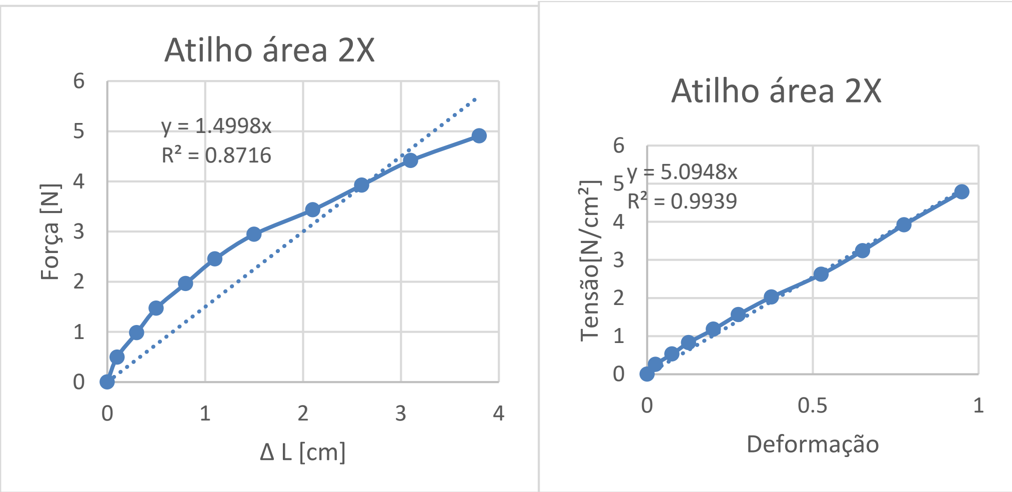


Tabela 1 – Dados experimentais obtidos

Área 1X			Área 2X		
Massa (g)	Força (N)	ΔL (cm)	Massa (g)	Força (N)	ΔL (cm)
0	0	0	0	0	0
50	0,495	0,20	50	0,495	0,10
100	0,981	0,60	100	0,981	0,30
150	1,4715	1,10	150	1,4715	0,50
200	1,962	1,60	200	1,962	0,80
250	2,4525	2,60	250	2,4525	1,10
300	2,943	3,40	300	2,943	1,50
350	3,4335	4,60	350	3,4335	2,10
400	3,924	6,40	400	3,924	2,60
450	4,4145	7,10	450	4,4145	3,10
500	4,905	8,50	500	4,905	3,80

A Tabela 1 apresenta os dados obtidos no experimento, para as duas áreas transversais dos atilhos, tendo-se como comprimento inicial a medida de 40 mm, obtendo-se os gráficos “Força x ΔL” e “Tensão x Deformação”, apresentados na Figura 2.

Figura 2 – Gráficos obtidos



(a) (b)

(a) Força X Alongamento

(b) Tensão X Deformação

Observa-se que se obtém a linearidade quando se estabelece a relação entre a tensão e a deformação (Fig. 2b), diferentemente do que ocorre na relação entre Força e alongamento (F X Δ L). Isto acontece pelo fato de a redução da área ser significativa ao longo da realização do experimento, o que gera uma falsa impressão de um Módulo de Young inicialmente alto.

3.2 Utilização da interação háptica com realidade virtual

Nesse experimento, o estudante usa um dispositivo háptico, exercendo uma determinada força (que irá variar conforme o material, o diâmetro e o comprimento do corpo de prova) e o resultado dessa força exercida, que em geral é transformada para valores substancialmente menores, porém proporcionais, é apresentado na tela do computador, a partir do diagrama tensão x deformação. De acordo com nossa experiência, essa ferramenta acaba sendo de extrema importância para o aprendizado dos conceitos iniciais da Resistência dos Materiais, a partir de uma atividade prática. As Figuras 3 e 4 apresentam a interação háptica desenvolvida para o ferro fundido e para o concreto armado. No detalhe inferior à direita, pode-se observar a interface usuário-computador e, ao lado, a figura de um ensaio de tração que responde à força exercida na interface. No gráfico à esquerda na imagem, plota-se o diagrama correspondente ao corpo de prova em análise no caso do ferro fundido.

Figura 3 – Modelo Háptico e Tela de Simulação (diagrama Tensão x Deformação do Fe fundido).

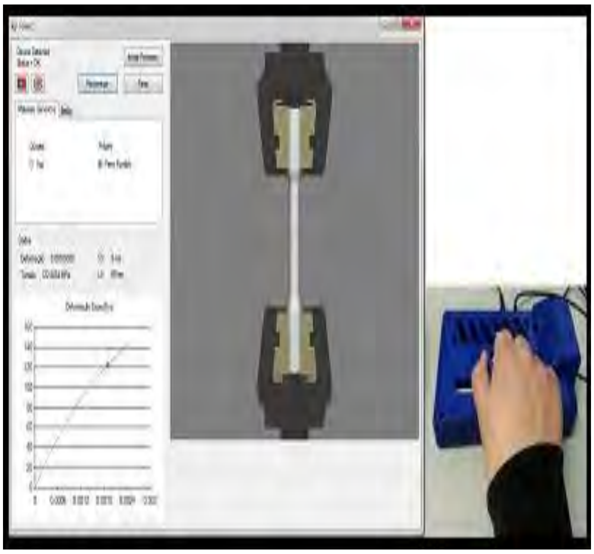


Figura 4 – Modelo Háptico e Tela de Simulação (diagrama Tensão x Deformação do Concreto)

4 Metodologia empregada na investigação

A experiência pedagógica foi realizada em uma turma de engenharia, ao final da disciplina de Física 3, pré-requisito para a disciplina de Ciência dos Materiais, após os alunos já terem conhecimentos básicos de mecânica e da Lei de Hooke. A aplicação da prática na turma teve como objetivo verificar a potencialidade do dispositivo háptico como recurso pedagógico.

Como em experimentos anteriormente realizados, a utilização do háptico como instrumento de aprendizagem passou por várias etapas:

- exposição da teoria pelo professor;
- aplicação de um pré-teste para avaliar os conhecimentos prévios dos estudantes;
- organização dos estudantes em grupos de dois ou três, para responderem em equipe questões envolvendo o háptico e outras questões teóricas;
- correção das atividades para o reconhecimento dos erros e acertos dos estudantes;
- avaliação do conhecimento dos estudantes através da aplicação de um pós-teste, composto por questões teóricas mais complexas;
- aplicação de um questionário sobre a atividade para verificar o conhecimento construído pelos estudantes e a satisfação dos mesmos com método de ensino utilizado.

As atividades demandaram um total de duas aulas de Física, o que equivale a aproximadamente de 6 a 8 horas em sala de aula.

Aplicadas todas as atividades, foram obtidas quatro notas de avaliação dos estudantes. As avaliações foram feitas para um total de 26 alunos, cujos resultados iniciais foram analisados a partir de um teste não paramétrico de Wilcoxon. As atividades foram sempre comparadas ao pré-teste, antes de os alunos terem explorado com maior profundidade o tema relacionado à resistividade dos materiais, mas terem tido apenas uma breve introdução ao assunto feita pelo professor. O quadro de notas foi separado nas seguintes categorias: Prova Inicial (pré-teste), Atividade em Grupo, Atividade com Háptico e a Prova Final (pós-teste). Como duas das atividades ocorreram em duplas, a nota da dupla foi dada individualmente para cada estudante, exemplo disto é se a dupla "Aluno 2" e "Aluno 3"formam uma dupla e receberam nota 5 na atividade em conjunto, cada Aluno receberá uma nota individual 5.

Ao comparar Prova Inicial *versus* Atividade em Dupla e Prova Inicial *versus* Atividade com Háptico não verificamos qualquer diferença, ou seja, as notas dos alunos na utilização do háptico e nas questões em duplas não são significativamente maior que as notas da prova inicial. Para o terceiro teste, comparando Prova Inicial *versus* Prova Final, notamos que a hipótese alternativa é válida, ou seja, as notas da prova final foram significativamente maiores que as notas da prova inicial. O nível de incerteza dos testes foi de 5%.

5 Considerações sobre os resultados encontrados na aplicação de estratégia pedagógica utilizando realidade virtual

Após analisar os resultados, pode-se observar uma significativa evolução na trajetória realizada pelos estudantes. Apesar de ter sido uma atividade realizada em final de semestre, em apenas três aulas, pode-se verificar um significativo engajamento por parte dos estudantes, revelando-se assim como uma importante estratégia para se levar a cabo a aprendizagem ativa. A primeira experiência relatada no item 3.1 também foi bastante interessante. Apesar de não ter sido realizado o Teste de Wilcoxon, contatou-se que os alunos obtiverem um significativo incremento de compreensão dos conceitos envolvidos na determinação do módulo de elasticidade.

6 Conclusões

No presente artigo, focou-se a aprendizagem de estudantes de um curso de engenharia tradicional acerca de esforços mecânicos a partir do uso de realidade virtual.

Conclui-se que, em geral, a opção por estratégias pedagógicas fundamentadas nos princípios da Aprendizagem Ativa parece contribuir positivamente para fomentar a aprendizagem dos estudantes em todos os níveis de um curso de engenharia e em qualquer área do conhecimento que seja objeto de estudos. No entanto, a eficácia dessas estratégias, enquanto promotoras da autonomia e da transformação desse estudante em engenheiro, requer um acompanhamento por parte do professor tal que permita identificar o patamar de desenvolvimento psicológico e intelectual desse estudante, sob pena de os esforços e os investimentos necessários para a implantação de estratégias ativas serem frustradas em seus propósitos.

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Application of the Project Based Learning Approach in the Aeronautical Turbine Disassembly J85 maintained by company Avio do Brazil controlled by GE Celma

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Abstract

This study integrates a more comprehensive research, called here a major research, whose central question is: How to apply the Project Based Learning (PBL) approach in a graduate course in production engineering? This paper presents the application of the initial model of the PBL approach in Production Engineering, proposed by the larger research, in one of the disciplines of the Synthesis and Integration content group that composes the backbone and conductive line of the Production Engineering training of the first undergraduate School of Engineering of Petrópolis, Federal Fluminense University. The purpose of the study was to present proposals for actions that allow the optimization of the flow of parts in the dismantling of one of the aeronautical turbines maintained by the GE Aviation from Brazil, controlled by GE Celma, both belonging to General Electric Aviation. For this, a project was developed to develop a plan to disassemble the most critical parts, containing the sequence of disassembly, removal and shipment of parts critical to the cleaning sector. During the project planning, criteria and tools to be used in the formulation of its deliverables were defined, as well as the criteria for selecting priority parts and the mapping of the dismantling process. The main results of the project were the detailed mapping of the disassembly process and ten improvement proposals for optimizing the flow of parts. The project proposals have already been implemented by the company and have helped to make the parts maintenance order more efficient and shorten the waiting time of the cleaning, repair and assembly sectors.

Keywords: Active Learning; Engineering Education; Project Approaches, Maintenance, Aeronautical Turbines.

Aplicação da Abordagem Project Based Learning na Desmontagem de Turbina Aeronáutica J85 Manutenida pela GE Avio do Brazil

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Resumo

Esse estudo integra uma pesquisa mais abrangente, chamada aqui de pesquisa maior, cuja a questão central é: Como aplicar a abordagem Project Based Learning (PBL) em um curso de graduação de engenharia de produção? Ele apresenta a aplicação do modelo inicial da abordagem PBL em Engenharia de Produção, proposto pela pesquisa maior, numa das disciplinas do grupo de conteúdos Síntese e Integração que compõe a espinha dorsal e linha condutora da formação em Engenharia de Produção do primeiro curso de graduação da Escola de Engenharia de Petrópolis da Universidade Federal Fluminense (UFF). O estudo teve como objetivo apresentar propostas de ações que permitam a otimização do fluxo de peças na desmontagem de uma das turbinas aeronáuticas manutenidas pela empresa Avio do Brazil, controlada pela GE Celma e ambas pertencentes à General Electric Aviation. Para isso, foi desenvolvido um projeto para desenvolver um plano de desmontagem das peças mais críticas, contendo a sequência de desmontagem, remoção e envio das peças críticas para o setor de limpeza. Durante o planejamento do projeto foram definidos critérios e ferramentas a serem utilizados na formulação de suas entregas, bem como, os critérios de seleção de peças prioritárias, e o mapeamento do processo de desmontagem. Os principais resultados do projeto foram o mapeamento detalhado do processo de desmontagem e dez propostas de melhoria para otimização do fluxo das peças. As propostas do projeto já foram implementadas pela empresa e ajudaram a tornar mais eficiente a ordem de manutenção das peças e a diminuir o tempo de espera dos setores de limpeza, reparo e montagem.

Palavras-Chave: Aprendizagem Ativa; Ensino de Engenharia; Metodologia Baseada em Projetos; Manutenção; Turbina Aeronáutica.

1 Introdução

As inovações tecnológicas do século XXI trouxeram consigo um mundo globalizado e altamente variável, onde o fluxo de informações e de novos conhecimentos são rapidamente atualizados e substituídos diariamente. Essa realidade trouxe uma gama de novos desafios para as empresas e os profissionais do terceiro milênio, que devem se adaptar a esse mercado volátil e imprevisível. Essa instabilidade acaba afetando a formação de novos engenheiros, em especial de produção, que devem reinterpretar os pilares de produção para o mundo globalizado do terceiro milênio. Uma das ferramentas utilizadas para responder esses desafios é a metodologia PBL, que consegue mesclar o conhecimento acadêmico com a experiência profissional do mercado de trabalho, permitindo que o universitário receba esse conhecimento de mercado e aplique o seu aprendizado para resolver problemas dentro da empresa.

No curso de engenharia de produção da UFF na cidade de Petrópolis, os alunos do quarto período são apresentados à metodologia e têm sua primeira experiência de resolução de problemas por meio de projetos com organizações parceiras. Esse estudo apresenta um exemplo dessa atividade, realizada com a empresa General Eletric Aviation, onde os alunos elaboraram propostas de ações para a otimização do fluxo de peças na desmontagem de uma das turbinas aeronáuticas manutenidas pela empresa.

Primeiramente, é apresentada uma revisão de literatura sobre PBL e sistemas de manutenção aeronáutica. Em seguida, é apresentada a metodologia da pesquisa e os resultados obtidos. O artigo é então finalizado com uma síntese dos resultados obtidos, com considerações e sugestões para trabalhos futuros.

2 Revisão de Literatura

A revisão de literatura estabelece o corpo de conhecimento sobre um determinado tema e facilita o desenvolvimento da teoria (Webster & Watsonalen, 2002). Esta revisão teve como objetivo fornecer os conceitos básicos sobre PBL e manutenção de turbinas aeronáuticas para o projeto executado em colaboração com a empresa.

2.1 Aprendizagem Baseada em Projetos

Segundo Krajcik e Blumenfeld (2006), os fundamentos do PBL foram estabelecidos pelo educador e filósofo John Dewey. Para Dewey (1959), os problemas do mundo real promovem o interesse dos alunos e provocam uma reflexão de como adquirir e aplicar novos conhecimentos em um contexto de resolução de problemas.

A abordagem PBL é organizada em torno de uma situação problema que promove a necessidade de aprendizagem de conhecimentos específicos, levando os alunos ao planejamento e execução de projetos que podem resultar em produtos para solução do problema proposto (Lima et al, 2007).

O planejamento e a execução de um projeto é a base da abordagem PBL, pois com ele os alunos aprendem os conceitos centrais de uma disciplina, aplicados na solução de uma determinada situação problema (Mills & Treagust, 2003).

Para Mills & Treagust (2003), uma abordagem mista, utilizando disciplinas tradicionais e disciplinas PBL nos primeiros anos de um curso de engenharia, pode ser uma maneira de satisfazer as necessidades da indústria, sem sacrificar o conhecimento dos fundamentos da engenharia.

Baseado em Powell & Wenk (2003), Lima et. al (2017) propõe uma abordagem que abrange todo o currículo, onde as disciplinas PBL visam a atingir os objetivos de aprendizagem do curso e as disciplinas tradicionais são utilizadas como apoio nesse processo.

Segundo Fink (2002), em 1974, a região North Jutland na Dinamarca, tinha uma grande taxa de desemprego, e por isso a Universidade de Alborg implantou cursos de engenharia, utilizando a abordagem PBL. Inicialmente, a aceitação pela indústria foi baixa, pois naquela época ainda se acreditava que os alunos de engenharia deveriam aprender apenas ouvindo seus professores e não realizando projetos em grupos. Mais tarde, a indústria da região percebeu que ter um grupo de alunos, estudando durante um semestre seus problemas de engenharia era uma maneira rentável de testar novas idéias e possibilidades. Atualmente, a região é um importante centro de competência para comunicações sem fio, e equipamentos para comunicações marítimas com cerca de 40 empresas.

O curso de engenharia de produção da Universidade Federal Fluminense (UFF) em Petrópolis iniciou suas atividades em novembro de 2015. O currículo do curso utiliza a concepção metodológica da Aprendizagem Baseada em Projetos (Project Based Learning - PBL) e foi estruturado de forma a privilegiar a atividade de projeto (UFF, 2014). A abordagem PBL é aplicada nos conteúdos Síntese e Integração que compõe a espinha dorsal e linha condutora da formação em Engenharia de Produção e atualmente já realiza projetos com algumas empresas do município.

2.2 Sistemas de manutenção de Turbinas Aeronáuticas

Segundo Ayeni et al (2011), a manutenção de turbinas aviônicas na indústria aeronaútica como função organizacional recebe mais dedicação acadêmica, do que a manutenção como atividade fim. Enquanto o setor de transporte aéreo é composto por empresas globais e regionais, o setor de manutenção de componentes é composto pelos poucos fabricantes de componentes que evitam compartilhar suas experiências.

A manutenção aeronáutica pode ser classificada como preventiva, corretiva ou preditivas (Knotts, 1999). Segundo Valentinavicius (2016), a manutenção de aeronaves realiza principalmente o tipo preventivo e suas atividades são divididas em dois nichos básicos: manutenção de base e de linha. O trabalho de manutenção de linha é especializado em cheques pré-vôos curtos, feitos em aeroportos e muitas vezes em condições externas. Inclui tarefas como assegurar o cumprimento das Diretrizes de Aeronavegabilidade ou Boletins de Serviço.

De acordo com Machado & Urbina (2011), apesar de estarem completamente associadas, possuem especificidades que as distinguem. A atividade de linha se refere à manutenção das aeronaves como um equipamento único, e a atividade de base se refere à manutenção dos componentes que servirão como insumos para a primeira. Os trabalhos de manutenção de base estão concentrados em todas as verificações de manutenção necessárias para atender aos requisitos de fabricantes de aeronaves e cliente. As atividades assumidas na manutenção base geralmente demoram um longo período de tempo. As tarefas são complexas, realizadas em ambiente de hangar fechado, e tem caráter sazonal (Valentinavicius, 2016).

3 Metodologia

Tendo em vista o escopo da pesquisa maior de mesclar a abordagem PBL com um curso de engenharia de produção, é possível observar que a disciplina PSP I funcionou como uma ponte para esse objetivo, já que levava o conhecimento profissional aos alunos através do estudo de caso.

Neste tópico será definido que tipo de pesquisa foi realizada, onde foi a unidade de análise, quais foram os procedimentos de coleta e análise de dados e as etapas para a aplicação da abordagem PBL.

3.1 Classificação da Pesquisa

O método utilizado na pesquisa foi o de estudo de caso que é caracterizado por uma análise empírica de um fenômeno presente na vida real, onde essa análise trata de uma situação única, resultando em várias fontes de evidências (Yin, 2001).

De acordo com a taxonomia de Cauchick (2012) foi possível determinar que a pesquisa apresenta uma natureza aplicada pois seus resultados podem ser aplicados ou utilizados imediatamente na solução de problemas reais. A pesquisa é exploratória, já que busca proporcionar uma familiaridade com o problema a fim de torná-lo explícito. O estudo envolveu o levantamento bibliográfico e entrevistas com pessoas que vivenciaram o problema pesquisado. Por fim, a atividade teve uma abordagem qualitativa pois houve uma relação dinâmica entre o mundo real e o sujeito que não poderia ser traduzida em números.

3.2 Unidade de Análise

A pesquisa foi realizada na GE Avio do Brazil, subsidiária da GE Aviation que está atualmente realizando manutenções da turbina J-85, utilizada no caça F-5 Tiger da Força Aérea Brasileira, e das LM 5000 e LM 6000, turbinas aeroderivadas, utilizadas em plantas de produção de energia a gás. A atividade foi realizada no setor de inspeção das turbinas J-85, onde acontece a desmontagem e a desmodulação dos componentes da turbina.

3.3 Procedimento de Coleta e Análise de Dados

Seguindo as orientações de Yin (2001), a coleta de dados foi realizada utilizando entrevistas, reuniões com funcionários da empresa e a partir de documentos fornecidos, a fim de utilizar diferentes fontes de informações. Os dados foram armazenados em documentos compartilhados entre os membros do grupo. As entrevistas foram gravadas e depois transcritas, permitindo assim uma melhor assimilação dos conhecimentos passados e um enriquecimento do banco de dados. Essas ações facilitaram a triangulação dos dados, permitindo assim uma conexão entre os documentos, as entrevistas e as próprias conclusões da equipe em relação aos problemas descritos.

3.4 Etapas de Aplicação da Abordagem PBL

Durante a realização do projeto foram utilizadas várias práticas de soluções de problemas e de gestão de projetos, afim de coletar requisitos e dimensionar limitações e riscos. Esse processo foi dividido em quatro etapas:

3.4.1 1ª Etapa – Definição da Situação-Problema e Elaboração do Termo de Abertura do Projeto

Para a realização do projeto, primeiramente foi formulado a situação problema, para isso foram realizadas reuniões semanais para a coleta de requisitos, para que fosse possível especificar com exatidão o problema que o cliente desejava que fosse resolvido. Em seguida, foi elaborado o termo de abertura, contendo de forma sucinta os requisitos das partes interessadas, os benefícios do projeto, a definição do produto e as justificativas do projeto. Por fim, o termo de abertura foi validado pelas as partes interessadas.

3.4.2 2ª Etapa – Elaboração do Plano de Gerenciamento do Projeto

Inicialmente foi realizado o planejamento do escopo, cujo objetivo era encontrar uma sequência de peças prioritárias que facilitassem o seu fluxo entre o setor de motor e o setor de limpeza, para o serviço de manutenção de revisão.

Em seguida, foi elaborada a Matriz de Rastreabilidade de Requisitos (MRR) e a Estrutura Analítica do Projeto (EAP), contendo os requisitos do produto e as entregas a serem realizadas pelo projeto. O produto final do projeto foi um plano de desmontagem para o fluxo das peças prioritárias entre o setor de desmontagem e limpeza. Para elaborar esse produto foram definidas as seguintes entregas: lista de peças prioritárias, motivos de priorização das peças da lista, procedimento de desmontagem das peças prioritárias e o livro de fotos. A gestão do tempo foi realizada com a ajuda do gráfico de Grantt, contendo a listagem de atividades e o tempo necessário para a elaboração das mesmas. A gestão dos riscos foi realizada com a ajuda da matriz de gerenciamento dos riscos, contendo a avaliação dos principais riscos identificados no projeto e as ações para prevenir e mitigar esses riscos.

O plano de desmontagem tem o objetivo listar, documentar e especificar a ordem de desmontagem das peças prioritárias. A lista de peças prioritárias contou com um levantamento das peças a serem priorizadas devido a sua vida programada, ordem de montagem, tempo de NDT, e de informações vindas dos outros grupos. O procedimento de desmontagem de peças priorizadas é um documento que ordena tarefas a serem executadas pelos mecânicos, durante a desmodulação da turbina.

3.4.3 3ª Etapa – Execução e Controle do Projeto

Nessa etapa foram feitas visitas técnicas semanais a empresa, onde o grupo tinha uma sala reservada para discussões com o engenheiro facilitador sobre as informações coletadas nas oficinas. Cada passo realizado foi acompanhado pelo engenheiro facilitador que orientou a execução do projeto e as modificações necessárias. Com as informações coletadas com os colaboradores da empresa, o grupo de alunos conseguiu definir o procedimento de desmontagem das peças críticas para o plano de desmontagem.

3.4.4 4ª Etapa – Encerramento do Projeto

O projeto foi encerrado com uma apresentação pública realizada na UFF, com a presença do engenheiro facilitador e do diretor da Avion do Brazil, professores e alunos. Na ocasião, o grupo entregou ao diretor da empresa o plano de desmontagem das peças prioritárias que foi o produto final do grupo e ao professor responsável pela disciplina PSP I foi entregue o relatório final do projeto. No encerramento da disciplina PSP I também foi realizada a avaliação do projeto, composta por uma autoavaliação e avaliação dos pares.

4 Resultados

Nesse tópico são apresentados os resultados obtidos durante a fase de execução do projeto. Inicialmente são apresentadas as análises realizadas e em seguida as propostas de melhorias identificadas.

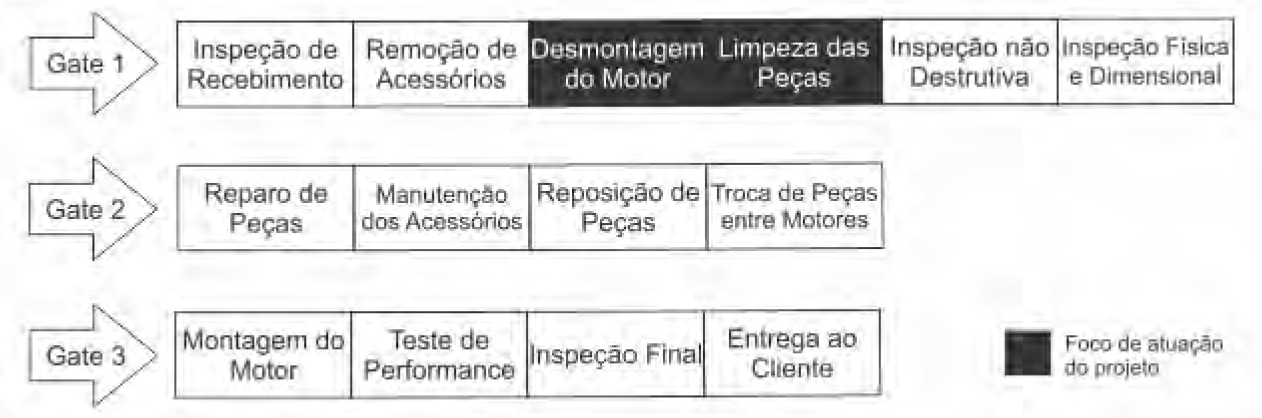
4.1 Análise da Situação Problema

A situação problema geral proposta pela empresa era otimizar o fluxo de peças para os vários processos do Programa de Manutenção da Turbina Aeronáutica GE J85-21C, com o objetivo de assegurar o cumprimento dos prazos contratados pelo cliente (FAB). A otimização ocorreu apenas em serviços de Revisão (Examinação Periódica), que são mais previsíveis em termos de workscope. De acordo com os representantes da GE Avio do Brazil, tal objetivo foi escolhido, para padronizar e documentar as prioridades na movimentação de peças entre os processos, que se feitas durante a produção, poderiam reduzir o tempo de revisão da turbina. A Figura 1 apresenta as atividades realizadas no processo de manutenção da turbina J85-21C.

Esse trabalho apresenta o estudo realizado pelo grupo que atuou na sequência de envio de peças entre a desmontagem do motor e a limpeza e que estão destacadas na Figura 1.

FIGURA 1: Sequência de atividades do processo de manutenção da Turbina J85-21C

Fonte: Avion do Brazil, 2017



Anteriormente o motor era inteiramente desmontado a nível de peça e enviado até a limpeza. A sugestão da empresa foi otimizar o fluxo por meio da priorização das peças críticas, utilizando critérios como peças com maior tempo de reparo, outside vendors, a ordem de montagem do motor, peças que necessitem de inspeção não destrutiva frequentemente e peças que necessitem de reparos com maior frequência.

A desmontagem anteriormente era realizada sem um sequenciamento programado, apenas respeitando as limitações impostas pela configuração inicial da turbina e eventualmente priorizando alguma peça selecionada pela engenharia.

Na primeira etapa do estudo foram selecionadas 23 peças consideradas críticas para a manutenção do motor no tempo contratado. O processo analisado foi o de desmontagem do motor, onde primeiramente a turbina é separada em módulos e em seguida é realizada a desmontagem de cada módulo, removendo todas as peças da turbina.

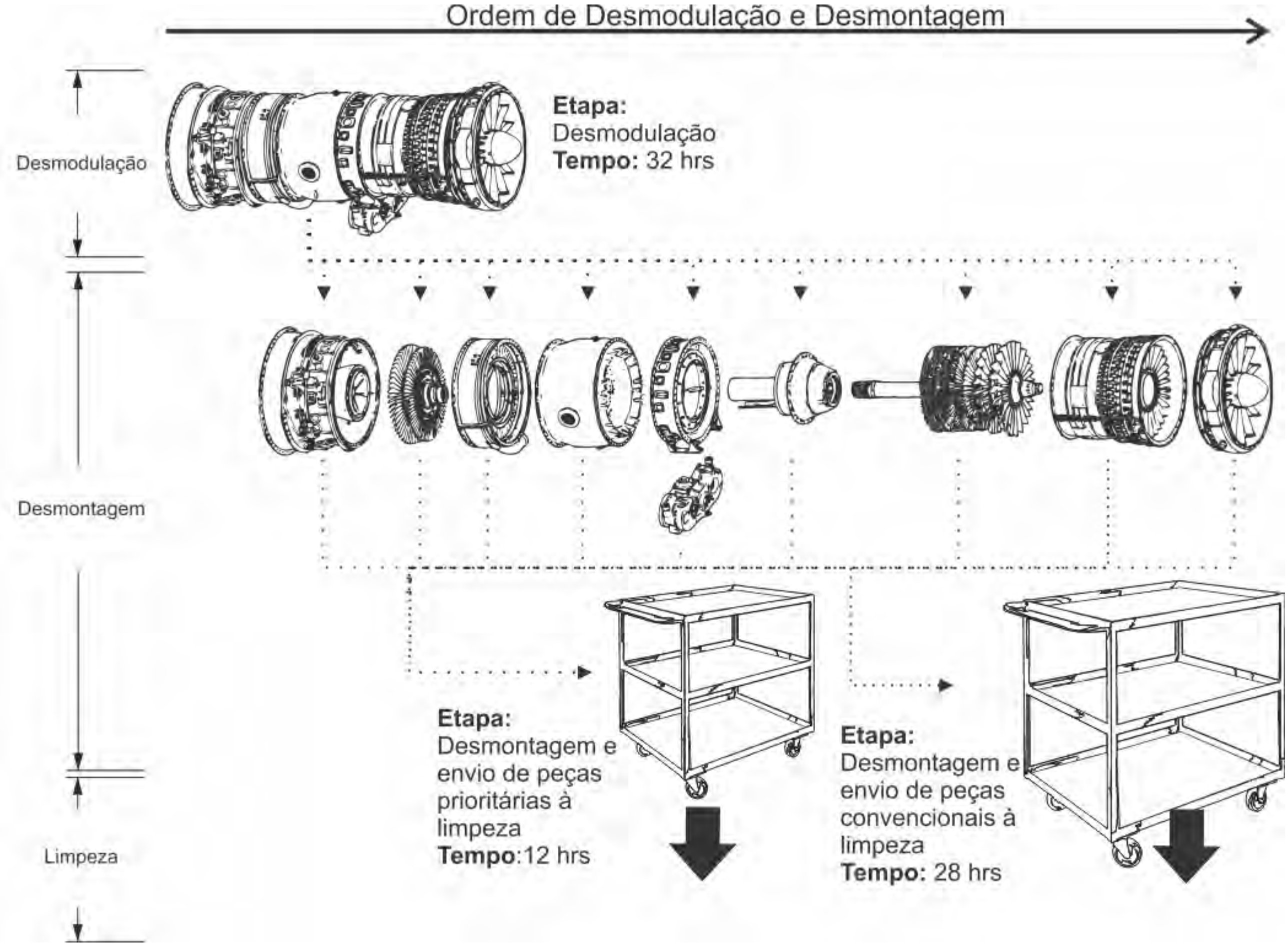
Visando compreender e coletar informações sobre a desmontagem e desenvolver o procedimento de remoção dessas peças críticas, evitamos mapear todo o processo de desmontagem a nível de tarefa, porque isso demandaria muito tempo. Os esforços foram direcionados para as demais entregas do projeto e para mapear a nível de tarefa apenas as atividades menores e que poderiam contribuir para tornar mais rápida a desmontagem das peças críticas.

Nesse estudo, processo é definido como um conjunto de atividades realizadas numa sequência lógica com o objetivo de produzir um bem ou um serviço que tem valor para um grupo específico de clientes (Hammer e Champy, 1994). O mapeamento do subprocesso de desmontagem foi realizado seguindo os passos preconizados por Biazzo (2000): definição das fronteiras e dos clientes do subprocesso, das entradas e saídas e dos atores envolvidos com o subprocesso; entrevistas com os responsáveis pelas várias atividades dentro do subprocesso e estudo de documentos disponíveis; e elaboração do fluxograma com base na informação adquirida. Esse mapeamento foi realizado através de entrevistas com os colaboradores envolvidos com o subprocesso, onde foram levantadas informações de como era feita a remoção das peças que devem ser priorizadas, a sequência mais simples para a desmontagem de cada peça crítica e o tempo de cada tarefa.

4.2 Proposta de Melhoria

A proposta desenvolvida pelo grupo de alunos envolve o uso de dois carrinhos, um contendo as peças críticas, denominado como carrinho prioritário, e outro contendo as peças não críticas. Os mecânicos devem começar a desmontagem seguindo o Procedimento de Demodulação, já existente na empresa. Em paralelo com o Procedimento de Desmontagem, uma instrução desenvolvida pela equipe de execução do projeto, que sequencia as atividades a serem executadas e leva o profissional a remover as 23 peças críticas colocando-as no carrinho prioritário. Este carrinho deve ser enviado de forma prioritária para o setor de limpeza, e mecânico pode continuar com a desmontagem das peças restantes, colocando-as no carrinho convencional.

FIGURA 2: Modificação no Processo de Desmontagem da J85-21C Fonte: adaptado da Avion do Brazil, 2017



5 Conclusão

A aplicação do PBL, se mostrou benéfica para todos os envolvidos, aprimorando a percepção dos alunos sobre as funções que serão desempenhadas ao longo da sua carreira, melhorando a contribuição da universidade para o desenvolvimento na região e originando ganhos para a empresa.

Com a implementação do carrinho prioritário, os setores de desmontagem e limpeza poderão trabalhar ao mesmo tempo num determinado motor, proporcionando uma diminuição do tempo de passagem do motor por esses setores.

O aumento do número de etapas diminuiu o tamanho dos pacotes de trabalho e ajudou a tornar mais flexível o processo, disponibilizando mais cedo para a montagem, as peças que eram geralmente responsáveis por criar atrasos. Com a implantação desses novos procedimentos, estima-se uma redução de 1,5 dias no tempo desmontagem e limpeza do motor.

Por fim, o trabalho de aplicação da abordagem PBL foi considerado satisfatório para todos os membros da equipe, pois permitiu aos alunos a obtenção de experiência de trabalho que eles só teriam acesso por ocasião da realização de estágios nas empresas.

A aplicação dessa metodologia em outros cursos deverá levar em consideração os limites de habilidade e de tempo dos alunos, como verificado na disciplina PSP I.

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Flipping the Mass Balance Class in Chemical Engineering

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Abstract

Critical thinking, problem solving and design that requires a lot of scientific and technical knowledge dominate chemical engineering courses, as well as the other engineering. However, these skills are failed in most of courses mainly for specific topics like crowded classroom, absence of professor/student contact and motivation, professor as the main protagonist of learning. To provide the desired above skills necessary for success in the chemical engineering fields, several pedagogical approaches can be used in order to avoid the cited problems. Flipped classroom is the methodology that reverses the logical of classroom. Student’s access theoretical content at home and in the classroom take the time to discuss the subject, solve problems and projects with the teacher’s help. In flipped classroom, the live class lectures are replaced by on-line videos or research or reading at home. Therefore, the classroom becomes a dynamic and interactive learning environment. The student turn into the protagonist of learning. In this way, the use of the flipped classroom was evaluated for the first time in the Mass Balance classes of Chemical Engineering Course at Federal University of Ceará, Brazil. The aim our study was to examine the effectiveness of the flipped classroom in learning basic concepts about mass balance. So, we prepared videos about the content, containing the basic concepts, examples of application and resolution of exercises. At home, the students also answer on-line quizzes containing theoretical questions about classes. In the classroom, the students used the time to solve problems and projects guided by the teacher. To measure the complete understanding of the subject-matter learning, we promote an exam based on the mass balance problems typical of chemical engineering process. The obtained results demonstrate that active learning flipped classroom promoted a better understanding of the content, with consolidation of the basic concepts, besides reducing the time needed to understand the subject addressed in the classes as compared with traditional classes.

Keywords: Active Learning; Engineering Education; Flipped Classroom; Blended Learning.

Invertendo as Aulas de Balanço Material em Engenharia Química

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Resumo

Pensamento crítico, solução de problemas e de projetos que requerem uma gama de conhecimentos técnicos e científicos são exigências nos cursos de Engenharia Química, como nas demais Engenharias. Sabe-se que tais princípios pedagógicos não encontram facilmente adesão nos processos de ensino e de aprendizagem. Um dos motivos diz da predominância das concepções tradicionais de ensino, que provocam passividade, repetição e baixa criatividade. Sala de aula invertida é uma metodologia que muda a lógica de uma aula tradicional, transformando o ensino desde o seu processo de planejamento. Esta metodologia ativa, inclui o protagonismo estudantil no alicerce das aprendizagens e refaz o papel do professor. Nesta abordagem, os estudantes têm acesso prévio ao conteúdo e estudam em casa. Na sala de aula, os mesmos utilizam o tempo para discutir, sistematizar e reelaborar o conteúdo, resolvendo problemas e projetos, momento em que o professor assume uma função de facilitador. Na sala de aula invertida, as aulas presenciais podem ser trocadas por aulas on-line por meio de vídeos. Além disso, os estudantes podem acessar os conteúdos por meio de pesquisas ou leituras prévias. Como consequências, os encontros presenciais se tornam mais dinâmicos e interativos. Neste sentido, este artigo analisa uma experiência pioneira, desenvolvida no curso de Engenharia Química da Universidade Federal do Ceará, Brasil, nas aulas de Balanço Material da disciplina Princípios dos Processos Químicos. Gostaríamos de descrever as mudanças que ocorreram em relação ao planejamento em geral e aos conteúdos e metodologias em particular, discutindo, por fim, as implicações nas aprendizagens após a sua implementação. A análise da compreensão dos assuntos abordados foi mensurada por meio de trabalhos em sala e também através de uma prova sobre problemas típicos envolvendo balanço material. O resultado obtido demonstra que a sala de aula invertida promoveu um melhor entendimento do assunto, com uma consolidação maior dos conceitos básicos, reduzindo o tempo necessário para o entendimento da matéria quando comparado com o método tradicional de ensino.

Palavras-chave: Metodologias Ativas; Educação em Engenharia; Sala de Aula Invertida; Ensino Híbrido.

1 Introdução

Um dos maiores problemas enfrentados pelos estudantes de Engenharia Química é a compreensão sobre a complexidade que envolvem os processos químicos industrias, o projeto e operação de plantas químicas. Por questões pedagógicas, de restrição à uma determinada pedagogia, os currículos de Engenharia Química, como os currículos das demais engenharias, são divididos em disciplinas fundamentais e de aplicação, sem que haja maior interligação dos conceitos, cálculos fundamentais e do projeto de processos.

Sabe-se que o estudante de Engenharia Química tem o seu primeiro contato com o mundo da Engenharia Química na disciplina que trata dos Balanços Materiais e de Energia. Normalmente, esta disciplina encontra-se na transição do ciclo básico para o ciclo profissionalizante e é uma espécie de "divisor de águas" no tocante à permanência do discente no curso. Após um período inteiramente voltado para disciplinas de cálculo, química e física, finalmente o estudante se depara a contabilização de propriedades em correntes de processos. Deste modo, entende-se que por ser uma disciplina introdutória ao curso e permitir a transição entre os conhecimentos das áreas que dão suporte ao entendimento e à prática profissional na engenharia química, estes estudos tornam-se basilares na vida acadêmica e a alicerce para os demais componentes curriculares do curso.

Compreende-se, assim, como e porque os balanços materiais e de energia são peças constitucionais no projeto de operações industriais, no dimensionamento de equipamentos ou no *scale-up*. Desta forma, o ensino nesta disciplina deve partir do entendimento do quanto o estudante necessita de uma compreensão adequada sobre o assunto para poder aplicar os princípios básicos da conservação da massa e de energia na contabilização exata das correntes de processos. Ela, por outro lado, requer, do estudante, um tempo necessário para a compreensão e o desenvolvimento dos cálculos. Um dos maiores problemas enfrentados por eles, segundo seus depoimentos, reside na dificuldade de interpretação adequada do problema para posteriormente estabelecer a rotina de cálculo e realizar os balanços, sendo esta interpretação, um grande problema para o processo de aprendizagem. Assim, interpretar deve aparecer como prioridade nas habilidades a serem enfatizadas no planejamento, de modo que ao acessar os conteúdos, não seja permitido sua mera repetição, mas se garanta criticidade necessária à projeção dos desafios profissionais e à resolução dos problemas de forma criativa, dando seguimento aos conhecimentos já acumulados pela ciência até aí.

Geralmente, pelo que observamos, as aulas são conduzidas pelo professor, são instrutivas e demonstrativas dos conteúdos, com metodologia que incorpora ao processo duas tarefas básicas: a explicação e a proposição de exercícios pelo professor e sua resolução por parte dos estudantes, caracterizando-se pelo tradicionalismo pedagógico (Luckesi, 1996, página 35). É notória a ênfase no individualismo, na passividade e na tentativa de homogeneização dos processos de aprendizagem, gerando repetição e baixa elaboração sobre o que se estuda. Os exercícios, mesmo que vinculados aos conteúdos científicos, nem sempre fazem a transição entre a ciência e a prática profissional, ou entre o ciclo básico e o ciclo profissional, como induz as proposições formativas dos engenheiros no nível inicial, apontado anteriormente. Além disso, não há um acompanhamento do processo de aprendizagem per si e, pela prática recorrente, se dúvidas surgirem elas só serão possíveis de serem sanadas após um certo tempo que compreende o intervalo entre uma aula e outra, não sendo a sala de aula um lugar de discussão. Este modelo tradicional de ensino não promove a interação entre os pares, não facilita o processo de apreensão da lógica e das habilidades requeridas, sendo, muitas vezes, um empecilho à aprendizagem ou um desestímulo à sua permanência no curso. Sabemos que as aprendizagens se dão em tempos, espaços e ritmos diferentes. Alguns retêm as informações em um ritmo mais acelerado, outros requerem um tempo maior. Alguns são mais autônomos, outros dependem mais de interlocuções com colegas e com o professor. Independentemente do número de alunos por sala, a heterogeneidade é notória. Como então acolhê-la como princípio do ensino e possibilitar que os conteúdos sejam acessíveis a todos, mesmo que reconheçamos suas diferenças?

Dentro deste contexto, o objetivo deste trabalho foi de avaliar o aprendizado dos alunos da disciplina de Princípios dos Processos Químicos do curso de graduação em Engenharia Química da Universidade Federal do Ceará, no ano de 2017, no que diz respeito ao conteúdo Balanço Material. Para tal, utilizamos a metodologia da Sala de Aula Invertida para a democratização deste conteúdo (Libâneo, 2008, página 45). Os estudantes tiveram acesso prévio ao conteúdo da disciplina por meio de vídeo aulas, contendo conceitos básicos, exemplos de aplicação e resolução de exercícios. Além disto, ainda de maneira não presencial, os alunos também puderam trabalhar os conceitos teóricos através de *quizzes* on-line, bem como realização de alguns trabalhos em equipe. Em sala, os estudantes formularam e tiraram suas dúvidas, realizaram trabalhos em equipe sob a tutoria do professor e também responderam *quizzes* e realizaram *games*. Todas as atividades foram devidamente registradas e tomadas como base de investigação sobre o que aprendiam, sendo, portanto, contabilizadas e mudando o sentido estanque dos processos avaliativos típicos do tradicionalismo do ensino, os quais são estanques e segregadores, pontuais e excludentes. No final de cada unidade, porém, foi realizado um exame para confirmar a consolidação dos resultados já sistematizados nas muitas atividades desenvolvidas neste período. Os resultados obtidos nesta unidade demonstraram que há maior atratividade no ensino, promovendo um melhor contato entre o professor e os estudantes, com uma maior consolidação dos conceitos, reduzindo assim o tempo destinado para atingir os objetivos quando comparado ao modo tradicional.

2 Conteúdo do curso, objetivos do aprendizado e sala de aula invertida

2.1 Disciplina de Graduação Princípios dos Processos Químicos na UFC

A disciplina TF314 – Princípios dos Processos Químicos – é a disciplina introdutória aos processos químicos do curso de Engenharia Química na UFC, sendo uma das poucas disciplinas da grade curricular com duração anual.

É nesta disciplina que os alunos têm o primeiro contato com os princípios e cálculos que envolvem os processos químicos e que envolvem a conversão de unidades e cálculos de propriedades e variáveis de processos, balanços materiais e balanços de energia em sistemas estacionários e não-estacionários, com ou sem reações químicas. Em outras palavras, a disciplina Princípios dos Processos Químicos (PPQ) refere-se à contabilização exata das correntes de processos que entram e que deixam os sistemas, seja em termos de matéria ou de energia.

A disciplina é dividida em tópicos que seguem o seguinte ordenamento:

- Sistemas de unidades e conversão de unidades:
- Cálculo e estimativa de propriedades de materiais envolvidos em processos incluindo: densidade, vazão, variáveis composicionais (fração molar e mássica, concentrações), pressão e temperatura.
- Balanços materiais em sistemas fechados e sistemas abertos; balanços materiais em sistemas simples (uma unidade); balanços materiais em múltiplas unidades envolvendo reciclo, purga e desvio, balanços materiais em sistemas com reação química; balanços materiais em sistemas com uma única fase; balanços materiais em sistemas multifásicos.
- Balanço de energia em sistemas fechados e em sistemas abertos; balanço de energia em dispositivos e equipamentos industriais; balanço de energia em sistemas com variação de temperatura e com mudanças de fases; balanço de energia em sistemas com reação química.

Tradicionalmente, as aulas eram conduzidas de maneira expositiva, com resoluções de exercícios para fixação do conteúdo. Em casa, os alunos resolviam exercícios selecionados pelo professor de maneira a complementar o assunto abordado. Ao final do conteúdo, uma avaliação era realizada. No final do curso, espera-se que o estudante seja capaz de identificar os tipos de sistema e de realizar os cálculos envolvidos nos processos de maneira coerente e precisa, baseados nas leis da conservação de massa e de energia. No ano letivo de 2017, nesta disciplina, o conteúdo de Balanço Material sofreu uma mudança metodológica em que foi totalmente trabalhado utilizando a metodologia da Sala de Aula Invertida.

2.2 Implementação da Metodologia da Sala de Aula Invertida

Na década de 90 do século passado, o professor Eric Mazur da Universidade de Havard, introduziu o conceito de *Peer Instruction* em suas aulas, tornando-se assim o precursor do que veria ser chamado de Sala de Aula Invertida. Nesta estratégia, os alunos acessavam o conteúdo previamente e respondiam a um questionário on-line sobre o assunto. A partir deste questionário, o professor identificava os principais pontos problemáticos e trabalhava os mesmos em sala de aula. Ainda em sala de aula, a discussão sobre o assunto e testes conceituais eram realizados em que os alunos sempre buscavam responder as próprias dúvidas. Sala de Aula Invertida, ou *flipped classroom*, foi popularizada após Bergman e Sams em 2006 introduzirem esta estratégia no ensino de ciências para o ensino médio (Bergaman e Sams, 2016). A metodologia da Sala de Aula Invertida é uma estratégia educacional que altera a lógica de uma sala de aula tradicional. Na metodologia tradicional, os estudantes recebem o conteúdo de forma expositiva pelo professor em sala de aula e após este encontro resolvem problemas, projetos e exercícios fora de sala. Na Sala de Aula Invertida, o material (ou conteúdo) é acessado pelos estudantes fora de sala de aula, seguido de aplicações na sala de aula (Felder e Brent, 2015). Em outras palavras, o aluno tem acesso prévio ao material do curso e que pode ser impresso ou on-line. Em sala de aula, o tempo da aula é destinado a discussão do conteúdo com o professor e os demais colegas, bem como resolução de problemas e projetos. Dentro deste contexto, a sala de aula se torna um ambiente mais dinâmico e interativo, permitindo um maior contato entre os estudantes e o professor, estimulando as atividades em grupo, os debates e discussão do conteúdo, o que favorece o aprendizado dos alunos.

Inicialmente, no começo do ano letivo, a introdução da metodologia ativa da Sala de Aula Invertida foi realizada pelo professor onde foi apresentada aos alunos juntamente com plano de ensino anual.

A metodologia da Sala de Aula Invertida foi utilizada nesta primeira parte do curso, especificamente para os tópicos Sistema de Unidades e Conversão de Unidades, Variáveis de Processos e Balanço Material. Em todos os tópicos, vídeos foram produzidos com duração inferior a 20 minutos contendo a exposição teórica e resolução de exercícios. Especificamente para Balanço Material, por se tratar de um assunto mais extenso, o tópico foi subdividido seguindo a seguinte sequência: (i) Sistemas fechados e sistemas abertos; (ii) Balanço material em unidades simples; (iii) Balanço material em unidades múltiplas; (iv) Balanço material em unidades com reciclo; (v) Balanço material em unidades com purga; (vi) Balanço material em unidades com desvio; (vii) Balanço material com reação química: relações estequiométricas; (viii) Balanço material com reação química: grau de conversão, rendimento e seletividade; (ix) Balanço material com reação química: extensão de reação; (x) Balanço material com reação química: balanço atômico; (xi) Balanço material com reação química: combustão; (xii) Balanço material em sistemas monofásicos.

As etapas do processo de inversão seguiram a seguinte ordem: (i) divulgação dos vídeos com antecedência mínima de uma semana; (ii) atividades em sala de aula – resolução de problemas, realização de *quizzes* e de *games*; (iii) atividades extraclasse – resolução de problemas desafios e *quizzes*.

As atividades realizadas em sala de aula consistiram em, inicialmente, uma breve discussão sobre o assunto abordado na vídeo-aula, seguida da formação de grupos para resolução de problemas. Nesta etapa, os alunos discutiam entre si a solução dos problemas e realizavam os cálculos devidos. O tutor (professor) circulava entre as equipes auxiliando, quando solicitado, na compreensão dos problemas e tirando dúvidas específicas. Ao final de cada atividade, a correção dos problemas era realizada.

Cada atividade realizada foi pontuada de forma que o somatório de todas elas contabilizaram 50% da nota da unidade. Ao final, uma prova escrita foi realizada individualmente e que correspondeu aos 50% restante da nota da unidade.

3 Relatos da Experiência e Discussão dos Resultados Obtidos

As atividades realizadas no primeiro semestre de 2017 na disciplina de PPQ foram acompanhadas por meio de uma planilha em que foram contabilizadas as atividades realizadas pelos discentes tanto em sala de aula quanto nas atividades extraclasse, o grau de participação nas atividades e o desempenho nas atividades em grupo. Os estudantes, em todas as atividades em sala, foram divididos em equipes. A depender da atividade, as equipes eram formadas por grupos de 3 a 5 alunos.

Em todas as atividades presenciais, os alunos foram encorajados ao trabalho em equipe em que era promovida a discussão a respeito dos problemas. Em conjunto, os alunos decidiam as hipóteses para realização dos cálculos devidos. O mesmo ocorreu para as atividades de "gameficação". Nestas atividades, foi utilizada a plataforma Kahoot!; um jogo sob a forma de perguntas e respostas onde os alunos, divididos em equipes, competiam entre si. Uma competição cujas perguntas estavam relacionadas com o tema da aula do dia e que também serviu como revisão para as avaliações e demais atividades. Ao final de todas as atividades, os resultados foram discutidos até a que a turma chegasse as respostas desejadas para as questões propostas.

A Figura 1a mostra uma atividade de trabalho em equipe para resolução de problemas ligados ao conteúdo de balanço de massa. A Figura 1b, por sua vez, mostra o exato momento em que os alunos disputavam a atividade de "gameficação". Em ambas as atividades, ficou evidente a dedicação e o engajamento dos alunos na realização das tarefas que discutiam os conceitos e as estratégias para a elucidação dos problemas ou dos questionamentos.

Figura 1. (a) Alunos em atividades de grupo para resolução de problemas; (b) Alunos em atividade de grupo disputando um jogo de perguntas e respostas.

(a) (b)

As atividades extraclasse consistiram em problemas desafios em que os alunos tinham um prazo determinado para solucionar as questões solicitadas. Além destes problemas, os alunos também responderam a *quizzes* on-line utilizando o aplicativo Socrative. Tais atividades serviram não só para a consolidação do conteúdo, mas também como uma revisão do assunto abordado em sala de aula.

No final do semestre, foi aplicado um questionário de forma anônima com perguntas objetivas e um espaço destinada críticas e sugestões, para que os alunos pudessem expor seu ponto de vista sobre a metodologia, seus questionamentos ou dificuldades. Os resultados para as questões objetivas são apresentados a seguir na Figura 2.

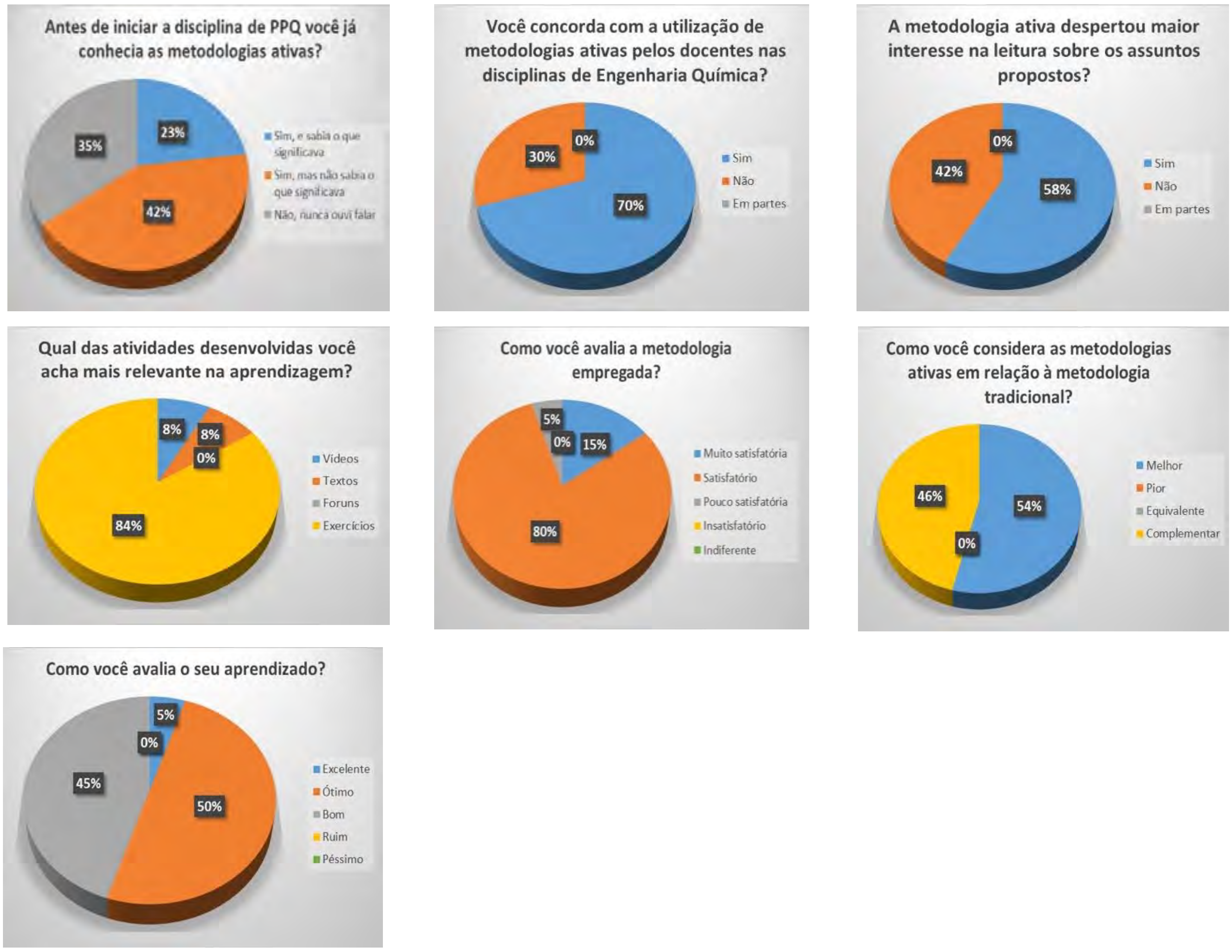
Dos 28 alunos matriculados na disciplina, 71,4% responderam o questionário, ou seja, 20 alunos no total. De acordo com a maioria dos estudantes, a metodologia ativa da Sala de Aula Invertida foi empregada de maneira satisfatória, promovendo uma maior interação entre os estudantes e com o professor, sobretudo nas atividades em sala (exercícios em grupo); momento em que havia um debate rico com o compartilhamento das dúvidas e construção dos conceitos. Entretanto, quase a metade dos alunos consideram as metodologias ativas e passivas complementares. No geral, os mesmos consideraram o aprendizado do conteúdo bastante satisfatório.

Ainda sobre o questionário, os alunos foram incentivados a deixar uma mensagem livre (criticas e sugestões) sobre a metodologia aplicada até o presente momento, com o intuído de melhorar a condução da disciplina. Foram identificados 3 conjuntos de resposta padrão, conforme mostrado na Figura 3. Dos 20 alunos que preencheram o formulário, apenas 15 deixaram suas opiniões sobre o andamento da disciplina.

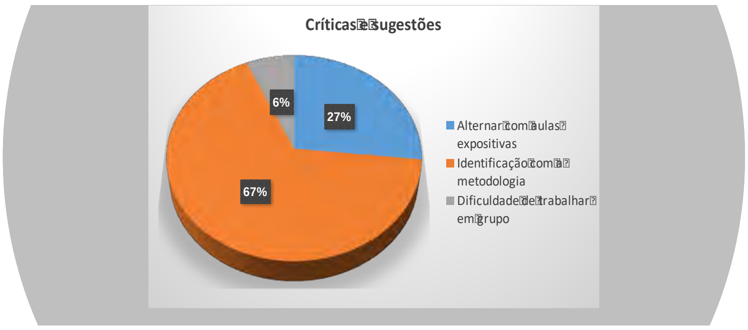
Nota-se que a grande maioria dos estudantes relataram uma maior identificação com a metodologia da Sala de Aula Invertida. Muitos afirmaram que o fato de poder trabalhar mais em sala de aula na resolução de problemas, de poder discutir e tirar suas dúvidas em conjunto com os demais colegas e com o professor contribuiu bastante para o aprendizado. Alguns ainda comentaram positivamente sobre a qualidade dos problemas propostos e o grau de complexidade. Percebe-se ainda que um grupo de alunos julgam necessário alternar a metodologia empregada com aulas expositivas (modo tradicional). Por fim, embora seja uma minoria, ainda há alunos que que preferem trabalhar de maneira individual.

De fato, por ser uma primeira experiência nesta disciplina, é uma quebra de paradigmas no ensino de Engenharia Química da UFC. Os alunos, embora se identificarem com a metodologia, ainda não estão totalmente acostumados com tal mudança. A alternância entre aulas expositivas e a Sala de Aula Invertida é perfeitamente justificável e salutar, desde que seja conduzida de forma a maximizar o aprendizado do conteúdo.

Figura 2. Resultado do questionário avaliativo da metodologia Sala de Aula Invertida aplicada na turma de Princípios dos Processos Químicos. Avaliação referente ao primeiro semestre de 2017



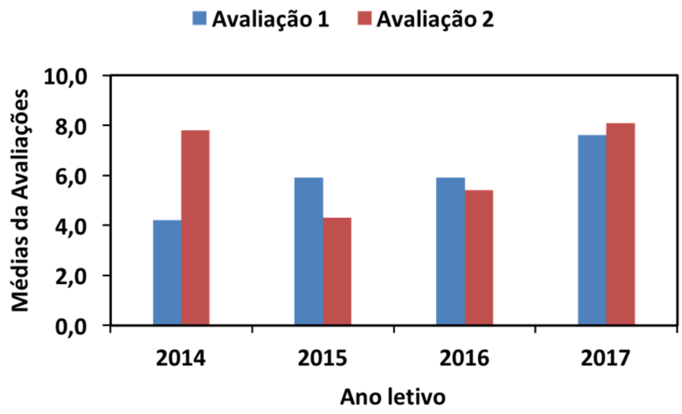
. Figura 3. Sugestões e críticas sobe a metodologia Sala de Aula Invertida aplicada na turma de Princípios dos Processos Químicos. Avaliação referente ao primeiro semestre de 2017.



Por se tratar de uma primeira tentativa de mudança metodológica, optou-se por realizar provas avaliativas, conforme mencionado anteriormente no tópico 2.2. Uma comparação foi ainda realizada entre os as médias alcançadas pelos estudantes, entre os anos de 2014 a 2017 (somente as provas individuais), em relação ao conteúdo da primeira e segundas avaliações. A primeira avaliação consistiu de uma prova com os assuntos Conversão de Unidades, Variáveis de Processos e Balanço Material. A segunda avaliação consistiu de uma prova com o assunto Balanço Material em Sistemas Monofásicos. Este resultado é apresentado na Figura 4.

Nota-se uma nítida evolução nas médias quando comparados os anos anteriores com o ano vigente de 2017. Este fato pode ser atribuído a um amadurecimento efetivo dos conceitos e do conteúdo por parte dos alunos, uma vez que eles trabalharam de forma mais intensa em sala de aula, com resolução de problemas e discussão em grupos, com ou sem auxílio do professor. As dúvidas que surgiram no decorrer das aulas eram sanadas no momento em que as mesmas surgiam. Os problemas resolvidos em sala e os trabalhos extraclasse, com diferentes graus de complexidade, também foram possíveis fatores que favoreceram, ao longo das aulas, a compreensão gradativa do assunto.

Figura 4. Comparação entre as médias obtidas pelos alunos na disciplina de Princípios dos Processos Químicos nas duas primeiras avaliações. Período de comparação: 2014 - 2016.



4 Conclusão

Diante dos resultados apresentados e dos depoimentos dos alunos é evidente que as mudanças metodológicas foram satisfatórias. A inversão da sala de aula auxiliou bastante para fundamentar e fixar o conteúdo, pois foram realizadas inúmeras atividades presenciais (solução de problemas) sob minha tutoria. O fato do aluno poder tirar suas dúvidas na hora que elas surgem durante a resolução de um problema é crucial no processo de aprendizagem. Além disso, apesar de não mencionado nas perguntas do questionário, os recursos tecnológicos utilizados facilitaram bastante a condução das aulas e a forma como os alunos estão encarando a disciplina.

Em suma, podemos considera que os objetivos de aprendizagem estipulados para o conteúdo Balanço Material foram atingidos, uma vez que os alunos foram capazes de estabelecer as hipóteses necessárias para resolução dos problemas e realizar os cálculos devidos com diferentes níveis de complexidade.

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The Use of Technological Resources in the Chemical Engineering Education

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Abstract

Blended learning, an active methodology in which students are distributed in the classroom in groups and oriented through digital activities, it has gained attention in education and has been applied in engineering courses. Activities carried out by digital medias are powerful tools in the teaching-learning process to fix basic contents, deepening of the concepts and in the simulation processes. In this context, the concept of blended learning and, more specifically, the flipped-classroom were applied Chemical Process Principles (basically, Mass and Energy Balance) and Mass Transfer Phenomena (Transport Phenomena III), respectively, in the undergraduate course of Chemical Engineering of the Federal University of Ceará. In the Mass Transfer Phenomena class, theoretical lecture and extra class activities were carried, such as on-line quizzes, on-line games, and project design apparatus for measuring properties. In Chemical Process Principles, flipped-classroom approach was used to teach mass balance. In addition, screencast videos online, on-line quizzes, on-line games, as well as teacher-led problem solving were employed during the course. In all cases, the use of technological resources, such as on-line video distribution tools, quizzes and games were useful for the involvement of the students, as well as for the consolidation of theoretical concepts. The results obtained in the exams are conclusive, with an increase in the passing rate in both disciplines.

Keywords: Blended Learning, Pedagogic Changes, Gamefication, Innovation in Engineering Education.

O Uso de Recursos Tecnológicos no Ensino de Engenharia Química

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Resumo

O Ensino Hibrido, metodologia ativa em que os alunos são distribuídos em sala de aula em grupos e orientados por meio de atividades digitais, tem ganhado atenção em educação em nível superior e tem sido empregada em cursos de engenharia. Atividades realizadas por meios digitais são uma ferramenta poderosa no processo de ensino-aprendizagem para fixação de conteúdo básico, aprofundamento dos conceitos e na simulação de processos. Neste contexto, o conceito de ensino hibrido e, mais especificamente, a sala de aula invertida foram empregadas nas disciplinas de Fenômenos de Transporte III e Princípios dos Processos Químicos, respectivamente, no curso de graduação em Engenharia Química da Universidade Federal do Ceará. Na disciplina de Fenômenos de Transporte III, alternando com as aulas expositivas, atividades de consolidação foram realizadas em sala de aula e extraclasse, tais como quizzes on-line, games on-line, projetos de dispositivos para medição de propriedades. Na disciplina de Princípios dos Processos Químicos, a metodologia ativa da sala de aula invertida foi utilizada para o ensino de balanço de massa. Nesta disciplina, além dos vídeos produzidos com o conteúdo da disciplina, os alunos realizaram quizzes on-line, games on-line, bem como a resolução de problemas orientados pelo professor. Em todos os casos, o uso de recursos tecnológicos, tais como ferramentas on-line de distribuição de vídeos, de questionários e jogos foram úteis para o envolvimento das turmas, para fixação do conteúdo teórico, bem como a consolidação completa dos conceitos teóricos. Os resultados obtidos nos exames são conclusivos com um aumento no índice de aprovação em ambas as disciplinas.

Palavras-chaves: Ensino Híbrido, Mudanças Pedagógicas, Gameficação, Inovação no Ensino de Engenharia.

1 Introdução

Os avanços tecnológicos nas últimas décadas têm proporcionado uma vasta gama de atividades interativas e que podem ser empregadas no ensino de uma maneira geral. No caso do ensino superior, essas mudanças podem proporcionar um movimento de reinvenção da educação, sobretudo no que diz respeito ao papel do professor em sala de aula. A esta reinvenção, cuja principal característica é a inversão dos papeis do protagonismo do conhecimento, dar-se o nome de metodologias ativas.

Em outras, este movimento pedagógico se denomina metodologias ativas de aprendizagem por colocar o estudante no centro do processo de aprendizagem e com um papel ativo na construção e criação do conhecimento, em vez de deixá-los ocupar um papel passivo nas salas de aula tradicionais, enfileirados e olhando para a frente, aguardando a transmissão de conhecimento de seus professores (Cavalcanti e Filatro, 2016).

Existem diversas abordagens das metodologias ativas de aprendizagem, dentre as quais podemos destacar Aprendizagem Baseada em Problemas (Araújo e Sastre, 2016), Aprendizagem Baseada em Projetos (Bender, 2014), Ensino Híbrido (Horn e Staker, 2015; Bacich, Neto e Trevisani, 2015), e Sala de Aula Invertida (Bergman e Sams, 2016). Dentre estas metodologias, o Ensino Híbrido (EH) e a Sala de Aula Invertida (SAI) fazem o uso de ferramentas digitais como auxiliares no processo de ensino-aprendizagem, alternando momentos presenciais e recursos de Ensino a Distância (EaD). Tal abordagem pode trazer diversos benefícios tanto para o aluno quanto para o professor. Para o aluno, o processo de aprendizagem se torna mais dinâmica, interativa e, consequentemente, mais atraente. Como consequência, o este modelo de aprendizagem rompe as barreiras do método tradicional e deixa o aluno mais no controle do seu processo de aprendizagem. Para o professor, esta metodologia lhe permite a busca por recursos diversificados. Assim, dependendo da ferramenta empregada, um acompanhamento adequado das atividades pode promover uma visão ampla (ou detalhada) da aprendizagem dos estudantes, facilitando o desenvolvimento de um plano de ação a ser adotado por aquele quando julgar necessário.

Com o propósito de melhorar os índices de aprendizagem e aprovação dos alunos do curso de Engenharia Química da Universidade Federal do Ceará, as metodologias do EH e SAI foram empregadas nas disciplinas de Fenômenos de Transporte III (FTIII) e de Princípios dos Processos Químicos (PPQ). Os resultados obtidos demonstraram um avanço significativo no processo como um todo, facilitando a compreensão de conceitos mais simples e os mais complexos, bem como na resolução de problemas.

2 Metodologias e Recursos Utilizados

Para a condução do EH e SAI nas disciplinas citadas foram utilizadas algumas ferramentas digitais de comunicação a fim de facilitar o compartilhamento do conteúdo desenvolvido com os alunos. O projeto ganhou o nome de ativaEQ, em alusão às metodologias ativas e ao curso de Engenharia Química. Um website (http://www.ativaeq.ufc.br) foi desenvolvido com o intuito de condensar em uma só plataforma o acesso a todo o material desenvolvido destinado aos alunos. Um canal na plataforma *YouTube* e uma página na mídia social *Facebook* também foram criados com o propósito de facilitar a disseminação daqueles materiais e auxiliar na condução das atividades realizadas durante o projeto.

No decorrer da implantação da metodologia algumas ferramentas digitais e on-line de transmissão e de avaliação de conteúdo foram utilizadas. As mais relevantes estão aqui citadas e descritas, bem como a metodologia utilizada no emprego de cada uma.

2.1 Vídeo-aulas

Vídeo-aulas já são massivamente empregadas por diversos profissionais como meio para transmissão de conteúdo. Para a condução deste projeto o uso deste recurso foi visto como algo útil e de grande potencialidade, utilizado apenas como ferramenta de transmissão dos conteúdos abordados.

Diversas vídeo-aulas foram produzidas ao longo do semestre com auxílio de monitores e colaboradores do projeto. Essas vídeo-aulas apresentam conceitos, aplicações e exercícios a respeito de um conteúdo abordado. Os vídeos foram disponibilizados no canal do *YouTube* criado propriamente para este fim (Figura 1) (www.youtube.com/c/ProfessorIvanildo).

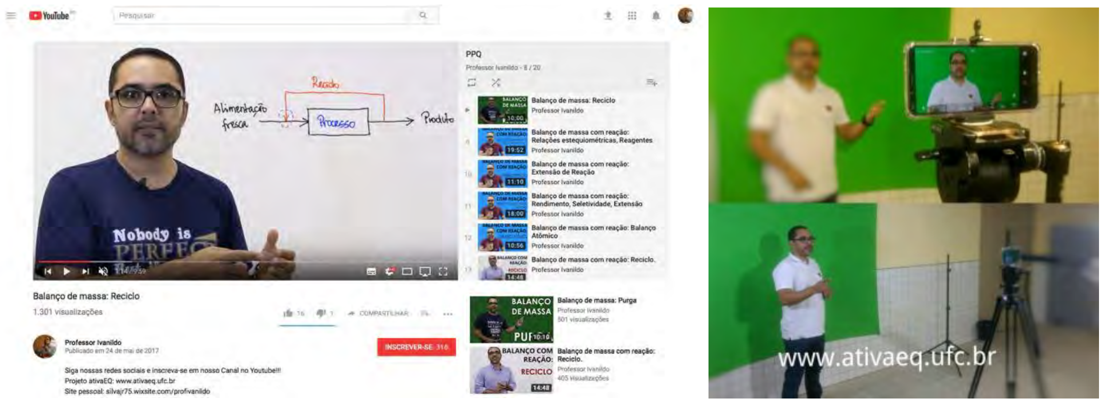


Figura 1. Canal no *YouTube* (esquerda), uma vídeo-aula de PPQ (meio) e um momento de filmagem para uma vídeo-aula (direita).

Com a criação das vídeo-aulas foi possível a implantação da metodologia SAI na disciplina de PPQ. Os vídeos eram divulgados para os alunos com alguns dias de antecedência da aula presencial cujo conteúdo do vídeo era abordado. Com isso os alunos tinham acesso prévio a explicação da matéria e então as aulas presenciais foram mais focadas na realização de exercícios. O maior benefício da abordagem desse método foi que os alunos puderam sanar suas dúvidas com o professor logo no momento que elas surgiam enquanto eles resolviam exercícios.

Durante o andamento das disciplinas, tanto PPQ quanto FTIII, alguns vídeos foram produzidos também pelos alunos em atividades específicas como registro de projeto ou como exposição de conteúdos pré-selecionados e sob a forma de trabalhos, conforme mostrado na Figura 2. Essa abordagem visou dar mais autonomia e responsabilidade aos alunos, pondo eles na posição de desenvolvedores de materiais de estudo.

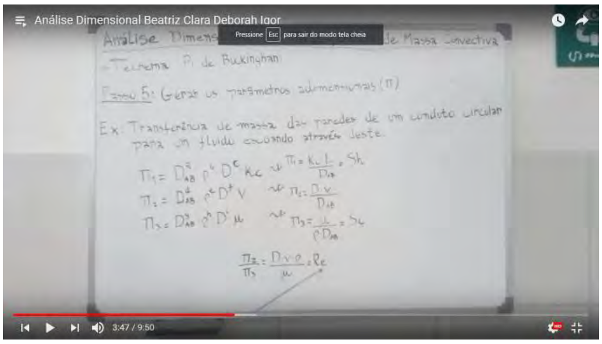
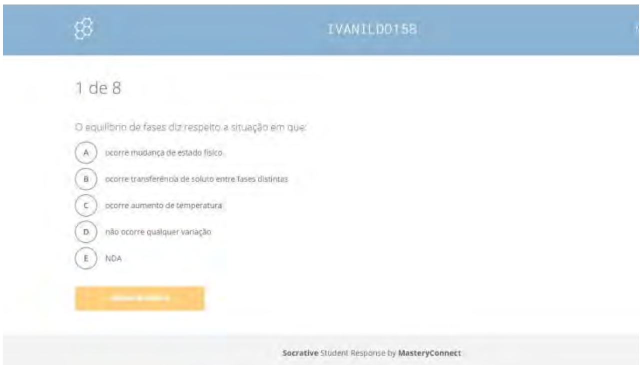


Figura 2. Atividade de projeto realizada na disciplina de FT3 (esquerda) e atividade de explicação de conteúdo realizada na mesma disciplina (direita).

2.2 Socrative

O Socrative é um aplicativo on-line que permite a criação de questionários com respostas discursivas ou de múltipla escolha. Este aplicativo permite ainda que o professor acompanhe e monitore em tempo real as atividades dos alunos, podendo ou não apresentar o *feedback* instantaneamente.

Esta ferramenta foi empregada como forma de avaliação dos alunos, logo após a divulgação das vídeo-aulas ou quando o professor julgasse apropriado (Figura 3). O professor criava os questionários e então divulgava os links destes para os alunos assim que a tarefa estivesse disponível, impondo também um horário de encerramento para resolução da tarefa. Os alunos respondiam às questões remotamente pela internet e o professor tinha então acesso às respostas de cada um, podendo assim fazer sua avaliação.



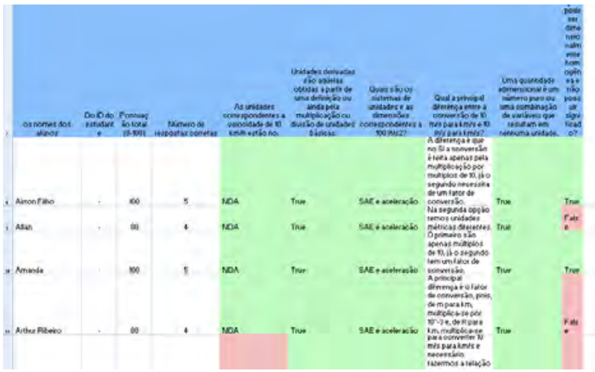


Figura 3. Atividade realizada pelo aplicativo Socrative (esquerda) e relatório gerado pelo aplicativo (direita).

Este aplicativo pode ser um grande aliado do professor, pois, a partir das respostas enviadas pelos alunos e de um gabarito pré-definido pelo professor, ele gera relatórios individuais ou gerais indicando que questões cada aluno acertou ou errou, ou também que questões tiveram um maior índice de erros e acertos por parte da turma. Com esses relatórios, gerados de forma simples e automática, o professor pode ter uma visão geral ou individual dos assuntos que precisam ser reforçados individualmente ou com a turma, possibilitando o desenvolvimento de um plano de ação para atacar as fraquezas que foram identificadas.

2.3 Kahoot!

O Kahoot é um aplicativo para criação de jogos de perguntas e respostas, funciona on-line e pode ser usado tanto em computadores, *tablets* quanto em *smartphones*. Ele funciona como uma plataforma onde o professor pode criar jogos de perguntas e respostas. Estas perguntas são projetadas na tela enquanto que os alunos acessam uma sala virtual pelos dispositivos eletrônicos e por onde respondem as perguntas quando devido. O professor coordena o jogo e os alunos participam como competidores, individualmente ou em grupos. A Figura 4 mostra a dinâmica desta atividade.

Esta ferramenta foi empregada ao longo do semestre, tanto como uma competição propriamente dita e valendo pontuação extra, como também uma forma de revisar os conceitos fundamentais. O professor criou os jogos e aplicou-os em sala de aula com os alunos dividindo a turma em equipes. Cada equipe tinha acesso a um celular com o aplicativo instalado e internet, podendo então entrar na sala virtual do jogo e competir.

Tal recurso é uma boa maneira de variar o estilo da aula e promover uma maior interação entre os alunos, promovendo as habilidades de trabalho em equipe, raciocínio rápido e espírito saudável de competição.

Figura 4. Animação do aplicativo Kahhot! (esquerda) e atividade em grupo realizada em sala de aula (direita).

3 Resultados das Avaliações Parciais e Percepção dos Alunos

A metodologia da SAI foi empregada na disciplina de PPQ, alternando em alguns momentos com o modelo tradicional de aprendizagem, caracterizando assim um EH. Além do acesso prévio ao conteúdo, por meio das vídeo-aulas, os alunos também realizaram quizzes on-line, games on-line e atividades extraclasse. Todas as atividades realizadas foram pontuadas e valeram 50% da nota global. Os outros 50% corresponderam a uma avaliação escrita. A fim de poder mensurar algum resultado, uma comparação entre as médias das avaliações parciais (provas individuais) sobre o conteúdo de Balanço de Massa (primeiro semestre de 2017) e os três últimos anos foi realizada (Figura 5). Percebeu-se um aumento considerável na média deste ano em relação a dos anos anteriores, em que foram empregadas a metodologia tradicional de aprendizagem.

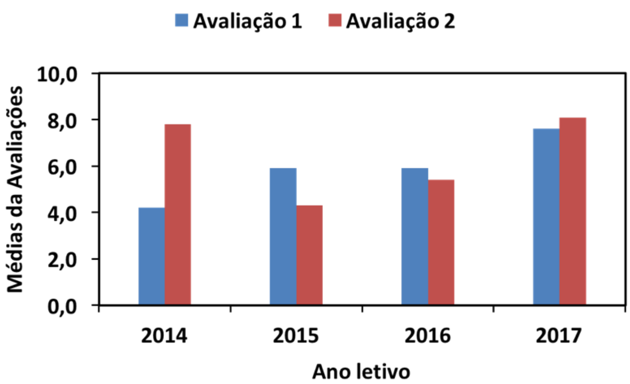


Figura 5. Comparação entre as médias obtidas pelos alunos na disciplina de Princípios dos Processos Químicos nas duas primeiras avaliações. Período de comparação: 2014 - 2016.

Ainda sobre a disciplina de PPQ, os depoimentos dos alunos demonstram uma completa satisfação no método empregado, uma vez que o processo de aprendizagem se tornou mais ativo. Os alunos perceberam que as atividades realizadas em sala de aula, sob a tutoria do professor auxiliou bastante para sanar quaisquer dúvidas porventura encontradas durante o momento de acesso ao conteúdo (fora de sala de aula). Além disto, as atividades on-line (quizzes e games) também contribuíram para consolidar os conceitos vistos em sala de aula.

Abaixo, podemos ver fragmentos dos depoimentos dos alunos, cuja versão completa está disponível em https://www.youtube.com/watch?v=hOXNdu-hTFE&index=9.

"Sobre os vídeos, você tem um material disponível a qualquer momento para estar exercitando o conteúdo, revendo alguns conceitos, eu acho isso muito importante. Sem falar dos exemplos resolvidos, que são de grande valia."

Depoimento do aluno 1 da disciplina de Princípios dos Processos Químicos.

"Com a nova metodologia o professor consegue abranger tanto o aluno que tem facilidade em estudar sozinho, como aquele que prefere estudar em sala de aula, porque ele usa a tecnologia como aliada. A tecnologia ajuda a manter o aluno com foco no seu aprendizado. Por meio principalmente da competição criada durante os exercícios em grupos e a gameficação (Kahoot!) as dúvidas são tiradas no meio da aula, assim, durante a competição você tem uma dúvida e no mesmo momento ela é sanada; essa é uma vantagem muito positiva. Com essa metodologia o aluno tem liberdade para manter o seu ritmo de aprendizagem [...] e de uma maneira leve e descontraída ele consegue tirar todas as suas dúvidas e assim ter um aproveitamento bem melhor durante as aulas."

Depoimento do aluno 2 da disciplina de Princípios dos Processos Químicos.

Com relação a disciplina de FTIII, aulas expositivas foram realizadas. Entretanto, em sala de aula foram realizadas muitas atividades em grupo, tais como resolução de problemas sob a tutoria do professor, quizzes e games on-line. Os alunos ainda realizaram atividades extraclasse: produção de vídeos didáticos com resolução de exercícios sob tema proposto pelo professor como também a construção de dispositivo experimental para medição de *difusividade* de líquidos voláteis. Nesta atividade, os alunos também produziram um material em vídeo registrando todo o processo, desde a construção, medição e os cálculos devidos. Os depoimentos dos alunos também foram coletados e estão disponíveis em https://www.youtube.com/watch?v=ak28eB29Ps0&index=24&list=PLdq4jQ_TlduG7wsrroZLftzaMSRipYSIy. Abaixo segue o fragmento de alguns depoimentos.

"A introdução do aplicativo Kahoot! em sala de aula, um aplicativo de perguntas e respostas que contribui para deixar o ambiente em sala muito leve através de dinâmicas em grupos referentes a todo o assunto estudado no semestre. Então eu posso contar para vocês que foi uma experiência muito enriquecedora e o modelo adotado muito legal, diferente de tudo aquilo que eu tinha visto, e o resultado foi muito bom, a turma abraçou o projeto."

Depoimento do aluno 1 da disciplina de Fenômenos de Transporte III.

"O professor introduziu novas metodologias que foram bastante eficientes para o meu método de estudo. [...] O professor deu metade de um determinado conteúdo em sala e a outra metade ele pediu que nós fizéssemos. Foi interessante porque era um conteúdo que já é vinculado com outra disciplina, então a gente pode fazer algo que além de multidisciplinar, a gente teve que estudar entender aquilo o suficiente para conseguir passar para outras pessoas, e você sabe que realmente aprendeu quando consegue passar para outras pessoas."

Depoimento da aluna 2 da disciplina de Fenômenos de Transporte III.

Como uma avaliação subjetiva sobre o projeto, ao longo do semestre foi perceptível uma maior disposição dos alunos em aprender o conteúdo, sobretudo por ter aulas mais dinâmicas e menos entediantes que as aulas nos modelos tradicionais de ensino. Além disto, uma vez que os conceitos e a resolução de problemas ter sido extensivamente trabalhado em sala de aula os alunos se sentiram mais a vontade às vésperas das avaliações, se opondo a um problema enfrentado por muitos professores em diversas disciplinas nas instituições de ensino.

4 Dificuldades Encontradas

A metodologia não foi perfeita em tudo. Por se tratar de um conceito novo no processo de ensino-aprendizagem na Engenharia Química da UFC, alguns problemas foram detectados ao longo do projeto. O mais desafiador durante o projeto foi majoritariamente a falta de estrutura das salas. Muitas atividades realizadas em sala exigiam conexão com internet sem fio que muitas vezes foram instáveis, bem como a disposição das cadeiras em fila. Entretanto, estas dificuldades não foram impeditivas para a condução das aulas. Assim, para que as metodologias pudessem ser empregadas, foi de vital importância a compreensão e apoio da administração superior (diretoria do centro de tecnologia) para com o projeto de modo a possibilitar que as aulas das disciplinas fossem realizadas ao longo de todo o ano em salas de aula com sinal de internet Wi-Fi disponível. Caso contrário a realização das atividades propostas para sala de aula dificilmente se tornariam viáveis.

Outro ponto importante diz respeito a resistência por parte de uma minoria de estudantes que ainda preferem o modelo tradicional de ensino. Alguns alunos julgaram a nova metodologia dispendiosa, um pouco trabalhosa e com excesso de atividades, tornando-se estes um pouco desinteressados durante o projeto. O desinteresse tem um grande impacto sobre o aluno em questão, dificultando que os benefícios dos novos modelos de aula e das novas metodologias fossem melhor aproveitados por este aluno.

5 Considerações Finais

Em resumo, apesar de pouco tempo de experiência podemos inferir que a adesão do EH nas duas disciplinas foi muito satisfatória. Uma das principais observações que podemos relatar diz respeito a forma como os alunos encararam as aulas; o meio e a facilidade como as aulas foram conduzidas, ajudando aluno e professor; a possibilidade de um método de aprendizagem mais leve e dinâmico, integrado ao mundo digital atual; e o mais vantajoso de tudo, as ferramentas quando aplicadas como suporte a exercícios durante as aulas possibilitaram ao professor sanar dúvidas enquanto elas surgiam.

A implantação das metodologias atreladas ao conceito de ensino híbrido exige esforço, tempo, dedicação e planejamento do professor, mas os benefícios são bem perceptivos e gratificantes. Alguns problemas também foram encontrados e precisam ser solucionados para se ter um melhor aproveitamento do método. Um espaço físico adequado para a execução do projeto é primordial, e em nem todos os momentos isso ocorreu, as salas de aula ainda precisam se adequar às metodologias de ensino que se diferenciam das tradicionais.

Algumas melhorias ainda precisam ser realizadas e um amadurecimento maior do projeto também se faz necessário, mas apesar dos problemas a utilização do ensino híbrido em disciplinas da engenharia mostrou-se muito positivo, com grande potencial e com boa aceitação.

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Interdisciplinarity in engineering education: a look from the perspective of projects

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Abstract

The world of work in today's times engages engineering professionals who can make the relationship between available technological resources and the problems belonging to the historical moment in which they live, to make decisions regarding economic, political, social and environmental aspects. Stimulating didactic and pedagogical proposals that interact with the aforementioned aspects can bring valuable contributions to significant changes in the engineer's performance. The light of the theoretical contribution of didactics in the teaching of sciences and engineering, about the debate on interdisciplinary proposals of teaching, this work aims to analyse a project-based approach, based on the didactic sequence proposed by Dym et. al. (2010), applied in the discipline of Topics in Electrical Engineering 2, curricular component of the 3rd period of the Electrical Engineering course of the Federal Rural University of Pernambuco. The first two stages of the model used (problem statement and problem definition) aimed at maturation of the proposed problem, making research and debates essential for the initially widely declared request to be transformed into an engineering problem. The next phase, the Conceptual Project, intended to explore the formal disciplinary contents, seeking to define the constraints and design requirements. It is in the later stage, denominated Preliminary Project that consolidate the solutions once idealized and tested in the form of prototypes. Product preparation and final project documentation are intended for the Detailed Project, Project Communication and Final Documentation phases. From the analysis of statements and questionnaires applied at the end of the project activities, it can be concluded that the division of activities in the described phases contributes to a better planning of the tasks, as well as stimulates the development of the skills and competences understood as essential to the understandings about the professional activities of today.

Keywords: Interdisciplinarity, Active Learning, Engineering Education, Project-Led Educational.

Interdisciplinaridade no ensino de engenharia: um olhar sob a perspectiva de projetos

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Abstract

O mundo do trabalho dos tempos atuais suscita a necessidade de profissionais em engenharia que possam fazer a relação entre os recursos tecnológicos disponíveis e os problemas pertencentes ao momento histórico o qual se vive, visando tomadas de decisões onde estejam considerados aspectos econômicos, políticos, sociais e ambientais. Estimular propostas didáticas e pedagógicas que interajam com os aspectos anteriormente citados, podem trazer contribuições valorosas para alterações significativas na atuação do engenheiro. A luz do aporte teórico da didática no ensino das ciências e das engenharias, acerca do debate sobre propostas interdisciplinares de atuação docente, este trabalho visa analisar uma abordagem baseada em projetos, a partir da sequência didática proposta por Dym et. al. (2010), aplicada na disciplina de Tópicos em Engenharia Elétrica 2, componente curricular do 3º período do curso de Engenharia Elétrica da Universidade Federal Rural de Pernambuco. As duas primeiras etapas do modelo utilizado (declaração do problema e definição do problema), visaram a maturação do problema proposto, tornando pesquisas e debates elementos essenciais para que a solicitação, inicialmente declarada de forma abrangente, fosse transformada em um problema de engenharia. A fase seguinte, o Projeto Conceitual, destina-se a exploração dos conteúdos disciplinares formais, buscando a definição das restrições e requisitos de projeto. É na etapa posterior, denominada Projeto Preliminar, que se consolidam as soluções outrora idealizadas e testadas em forma de protótipos. A preparação do produto e documentação final de projeto ficam destinadas as fases do Projeto Detalhado, Comunicação do Projeto e Documentação Final. A partir da análise de depoimentos e questionários aplicados no final das atividades de projeto, pode-se concluir que a divisão das atividades nas fases descritas colabora para um melhor planejamento das tarefas, como também estimula o desenvolvimento das habilidades e competências compreendidas como essenciais aos entendimentos sobre as atividades profissionais dos dias de hoje.

Keywords: Interdisciplinaridade, Aprendizagem ativa, Educação em Engenharia, Project-Led Educational.

1 Introdução

A formação de futuros engenheiros deve promover uma nova postura desses profissionais, seja perante o mercado de trabalho ou mediante os problemas atuais da sociedade, sugerindo a reconstrução das estruturas didáticas e pedagógicas das aulas e cursos em engenharia. Visando atender esse propósito, a Universidade Federal Rural de Pernambuco (UFRPE) vem investindo no estímulo e capacitação docente para a utilização de metodologias ativas de aprendizagem desde a criação do Campus das Engenharia, denominada por Unidade Acadêmica do Cabo de Santo Agostinho (UACSA) no ano de 2014.

A proposta assumida pela referida universidade está baseada na estruturação de projetos interdisciplinares através de uma Aprendizagem Baseada em Projetos (ABP). Segundo Filho e Ribeiro (2009), a ABP surgiu, de forma estruturada, na escola de medicina da Universidade McMaster, no Canadá, no início dos anos 60, também em cursos de medicina. Os autores em tela denominam a ABP como sendo "essencialmente um método de ensino-aprendizagem que utiliza problemas da vida real (reais ou simulados) para iniciar, enfocar e motivar a aprendizagem de teorias, habilidades e atitudes" (p. 24). Sendo assim, a ABP apresenta elevado potencial para promover a interlocução da vida real com os conceitos teóricos, práticos e tecnológicos, quando aplicados aos cursos de engenharia.

Vários são os modelos para se trabalhar com projeto para fins educacionais. No entanto, há uma confluência de ideias no que diz respeito às motivações, princípios e elementos característicos de uma proposta baseada em projetos. A Aalborg University (Barge, 2010) propõe como pilares na concepção de atividades em ABP (i) a proposição orientada de um problema, (ii) a organização do projeto, (iii) a integração entre a teoria e a prática, (iv) a autonomia dos estudantes na tomada das decisões do projeto, (v) o estímulo ao trabalho em grupo e (vi) a colaboração mútua entre estudantes e professores no estabelecimentos de metas e discussão de resultados. Percebemos que essas características também se encontram presentes no guia para a aprendizagem baseada em projetos do Buck Institute for Education [BIE] (2008), com sede nos EUA.

Na perspectiva educacional apresentada pela Agência Porvir, a Aprendizagem Baseada em Projetos está ancorada em elementos essenciais (Agência Porvir, 2017). O primeiro elemento consiste na explanação de um **problema ou questão desafiadora**, o que faz suscitar nos estudantes o **espírito de exploração** para busca de uma solução. O **produto a ser apresentado** receberá, durante o percurso de sua elaboração, **crítica, revisões e reflexões**, até que se chegue a uma melhor solução. Dado que os problemas são abertos, cada **aluno terá voz** na construção do projeto, acarretando em decisões **originais**. Todos esses elementos devem ser trabalhados para que se construa nos estudantes os principais conhecimentos e habilidades apontados no relatório internacional da UNESCO (Delors, 1996), sobre a Educação para o século XXI, aportadas em quatro pilares que são:

- Aprender a conhecer (aprender a aprender), onde se possam ser trabalhados aspectos de uma cultura geral agregadas a formação profissional, visando "beneficiar-se das oportunidades oferecidas pela educação ao longo da vida" (p.29).
- Aprender a fazer, e ir além de uma formação estritamente profissional, estando preparado para trabalhar em equipes e vir a alocar conhecimentos em diversos contextos;
- Aprender a conviver, respeitando o pluralismo, a compreensão do outro, e preparando para o reconhecimento das interdependências, ou seja, estar apto ao gerenciamento de conflitos e a realização de projetos comuns em uma cultura de paz;
- Aprender a ser, e "construir sua personalidade em condições de agir com uma capacidade cada vez maior de autonomia, discernimento e responsabilidade pessoal" (p.29), estando a educação possibilitada a estimular as potencialidades individuais em prol do coletivo, desenvolvendo a memória, capacidade de comunicação, raciocínio, sentido estético e capacidades físicas.

Visando o desenvolvimento de projetos interdisciplinares e uma aproximação maior do estudante de engenharia com o mercado, a UFRPE-UACSA promoveu a inserção de quatro disciplinas na grade curricular de cada um dos cursos de engenharia por ela ofertados, denominadas Tópicos de Engenharia. A experiência na adoção de uma das formas de abordagem em projetos, realizada na disciplina de Tópicos de Engenharia Elétrica 2, do curso de Engenharia Elétrica, para uma turma de aproximadamente de 25 estudantes, é o objetivo central deste trabalho.

2 Fundamentação teórica: a sequência didática

A elaboração dos projetos será realizada ao desenrolar de uma sequência didática conforme proposto por Dym, Little, Orwin, e Spjut (2010), cujo fluxo explicativo sobre as etapas constituintes de toda a sequência didática pode ser visualizado na Figura 1. O momento inicial a apresentação do problema, primeiro elemento esencial da ABP. Em Dym et al. (2010), o momento posterior a declaração do problema deve ser reservado a pesquisas e discussões, para que a solicitação explanada seja compreendida como um problema de engenharia, uma vez que o enunciado poderá conter lacunas e soluções imediatas que talvez não levem a resolução da questão.

Transformar um desejo em um problema da engenharia requer uma análise de atributos, funções e requisitos de projeto, que uma vez negociado com o requerente, levará a solução do problema proposto (Dym, 2010). Nesse caso, serão realizadas seções onde os alunos possam discutir os aportes teóricos que podem subsidiar o encontro de uma solução, como também o estabelecimento de objetivos e métricas.

Esse momento é de suma importância para o desenvolvimento do projeto, haja vista que é no nascimento das soluções que devem ser explorados os conteúdos curriculares, como também é o momento oportuno de serem avaliadas diversas soluções, pois, a possibilidade de alterações significativas torna-se menor em etapas mais adiantadas do projeto. É nesta fase também que os trabalhos devem levar o grupo a formatar uma lista de restrições, para que a solução encontrada não venha a ter funções desnecessárias (Dym et al, 2010).

Com o discernimento de qual problema será resolvido, chega-se ao momento onde a solução começa a ser construída. Ao possuir os objetivos e restrições, podem ser construídas as funções e requisitos do produto a ser desenvolvido, como também são geradas alternativas de projeto, promovendo um ambiente propicio a discussões e posterior tomada de decisões sobre a escolha de um projeto. Todas as definições deverão um projeto conceitual, compreendida como a chegada de um consenso sobre a solução a ser construída.

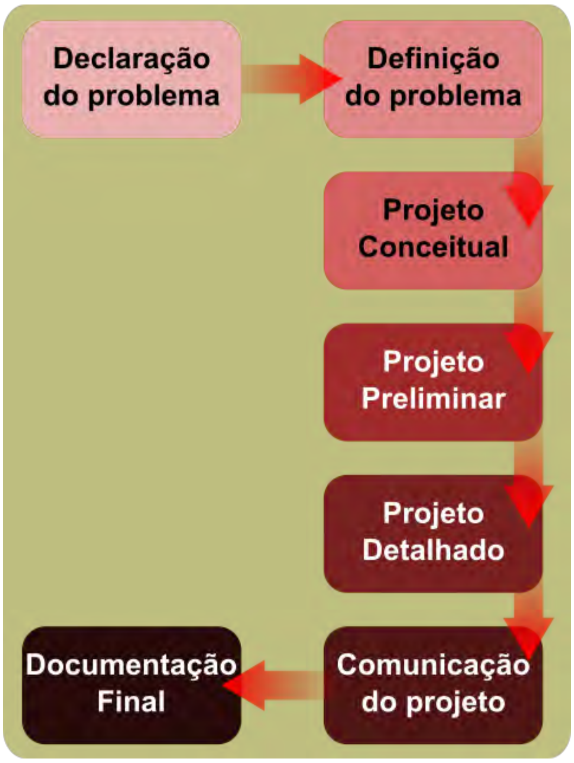

Figura 1: Fluxo do Projeto (Dym et. al. p. 47)

As primeiras atividades direcionadas a construção física do produto está apresentada no fluxo como projeto preliminar, oportunidade na qual os conhecimentos começam a ser aplicados de forma prática, levando os estudantes aos testes, simulações, modelagem e construção do produto. A esse momento enriquecedor, seja na mobilização dos conteúdos estudados, como na aplicação dos mesmos em uma situação real, atribui-se a confecções dos protótipos, definido por Dym et al. (2010) como sendo as "primeiras formas em escala natural e normalmente funcional de um novo tipo ou projeto de uma construção" (p. 185).

A fase correspondente ao projeto detalhado pode ser compreendida como o momento onde, realizados os testes e simulações, os estudantes se voltam para a os ajustes finais de projetos, como também passam a ter em mente critérios estéticos, de design e de comunicação das soluções encontradas e construídas. Faz-se necessário, então, fornecer um feedback de toda a experiência e das informações elaboradas para o requerente.

Preparar a comunicação do projeto demanda que o grupo, enfim, organize as informações no intuito de mostra-las ao requerente, sendo necessária a descrição do processo do projeto, a entrega de desenhos e detalhes do produto, como também as especificações para um processo de fabricação (Dym et al., 2010). Há de se pensar, nessa fase, numa melhor forma de fazer a documentação final e apresentação do produto, levando-se em consideração a especificidade de público ao qual serão direcionadas essas explanações.

3 Desenvolvimento das atividades: a experiência

As atividades iniciais de projeto tiveram como foco a formação dos grupos e a criação de uma identidade visual, onde fora solicitado a escolha de um nome e logotipo para o grupo (Figura 2). Conforme o diagrama contendo o Fluxo do Projeto, a primeira etapa consiste no anúncio da questão norteadora dos trabalhos. Para Bender (2014) essas questões deverão ser explicitadas de "maneira clara, e ser altamente desafiadora" (p. 17). Nas recomendações de Patton (2012), além dos problemas surgirem de uma situação real, estes precisam surgir de "um problema que tenha significado para os alunos" (p.40), como forma de comprometê-los com o andamento do projeto.

Figura 2: Identidade Visual de um dos grupos

O problema fora elaborado a partir da atuação profissional do primeiro autor deste trabalho, no qual se depara com a seguinte situação abaixo descrita.

"Para a proteção de linhas elétricas em baixa tensão, são utilizados disjuntores. No entanto, o preço constante nas tabelas de referência para o serviço público, para esse equipamento, é único para disjuntores que possuem corrente nominal até 30A. Seria possível construirmos um equipamento digital, que pudesse ser ajustável, e atuasse da mesma forma que os disjuntores comerciais, ou seja, preservadas suas funcionalidades térmicas e eletromagnéticas?"

Após declarado o problema, os estudantes foram instigados a buscar informações sobre o funcionamento dos disjuntores de baixa tensão. Em um primeiro momento de exploração, cada grupo ficou responsável por explanar, ao restante da sala, aspectos construtivos e funcionais dos disjuntores. Visando elucidar questões que porventura ainda se fizessem presentes, o professor da disciplina de Instalações Elétrica, da mesma unidade de ensino, fez uma explanação sobre a forma de atuação dos disjuntores. Esse momento foi de suma importância para o andamento do projeto, pois foi através dele que os estudantes conseguiram, enfim, definir claramente o problema de engenharia: seria na interpolação da curva de disparo do disjuntor (Figura 3) onde ocorreriam os ajustes de atuação do equipamento.

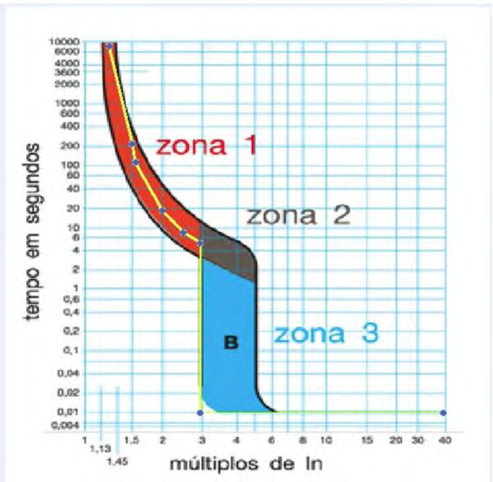

Figura 3: Apresentação de proposta para atuação do disjuntor (linha amarela)

O segundo momento de interdisciplinaridade na execução do projeto consistiu na interpolação da curva de atuação do disjuntor, utilizando-se conceitos de disciplina de Cálculo Numérico. A partir de então, a tarefa consistiu na obtenção de conhecimentos que tornassem os alunos aptos a desenvolver as linhas de programação na plataforma de prototipagem eletrônica Arduino, como também fossem capazes de montar o circuito responsável pelo chaveamento do equipamento nos momentos desejados.

O aglomerado de informações captadas resultou na formatação do projeto conceitual, documento formado por informações como relatos sobre o andamento das atividades, material utilizado, custo estimado, divisão de tarefas, fontes de consulta, e as definições técnicas do artefato solicitado, configurando a primeira parte de instrumento de coleta de dados para avaliações. As fases seguintes, relacionadas a construção do protótipo e a apresentação final do produto, desenvolveram-se em consequência as etapas anteriormente descritas, resultando em equipamento capaz de ser ajustável para correntes de 1 a 30A, programado para atuar em disparo de acordo com as características térmicas e magnética presentes nos disjuntores comerciais.

A proposta avaliativa do projeto deu-se a partir da compreensão dos apontamentos de Luckesi (2011). Neste, pode-se encontrar a proposição de dois tipos de aprendizagem. A primeira delas, intitulada aprendizagem de domínio, diz respeito à apreensão de conteúdos em um nível mínimo necessário para a compreensão de um determinado conteúdo, salvaguardada as proporções em determinados níveis escolares. O aprendizado de desenvolvimento, segundo conceito discutido, refere-se à aplicabilidade destes ensinamentos, seja na utilização em níveis mais avançados de compreensão, como também na solução de um problema cotidiano da vida real.

Para abarcar as duas dimensões da aprendizagem conforme apresentada anteriormente, vários pontos de controle foram definidos durante a execução do projeto, para que a avaliação pudesse ocorrer em cada uma das etapas sugeridas por Dym et al. (2010), onde pode-se visualizar os diversos momentos avaliativos através do quadro abaixo (Figura 4). Além das etapas previstas no modelo adotado, podem-se perceber dois relatórios adicionais, que versam sobre recursos utilizados, conteúdos explorados, linha do tempo e mobilização da equipe.

Integrantes	Logo	Apresentação partes do DJ	Relatório de andamento 01	Projeto de Conceitos	Protótipo	Relatório de andamento 2	Produto Final
Clinton, João Neto, Lucas Henrique, Márcio Amorim, Victor Verçosa	OK	OK	OK	OK			

Figura 4: Momentos de avaliação - Pontos de Controle

Ao fim das atividades do projeto, as atenções se voltaram para buscar compreender como os estudantes avaliariam a experiência com a aprendizagem por projetos, com o foco voltado a percepção dos alunos acerca dos aspectos práticos da sequência didática, pois, concordamos com Fernandes, Flores e Lima (2010) quando apontam que a “componente prática que o projeto engloba constitui uma fonte de motivação para os alunos, tornando visível a aplicação prática dos conceitos, o que confere ao projeto um carácter mais real e articulado com o contexto profissional futuro” (p. 72).

Em uma sequência didática através de uma metodologia ativa como a ABP, ressalta-se a importância em “relacionar conteúdos interdisciplinares de forma integrada” (Fernandes, Flores & Lima, 2010). Para a experiência observada neste trabalho, é notório a tomada de consciência dos estudantes na utilização de conteúdos da disciplina de Linguagem de Programação e Cálculo Numérico.

Ainda durante a apresentação final do projeto foram gravados depoimento em áudios visando perceber, a partir da fala dos estudantes, de que forma as outras disciplinas da grade curricular agregaram ao projeto, como também a perspectiva de utilização dos conhecimentos desenvolvidos durante o projeto na atuação enquanto profissional da área, o que pôde ser observado na transcrição da fala dos estudantes.

> *No futuro vamos trabalhar com isso, teremos que programar, e isso nos dá uma base. Monitorando através do computador, análise de dados, saber o que o computador tá te informando através da programação.*

Além das transcrições, um questionário fora elaborado para que os alunos pudessem externar fraquezas e potencialidades durante a realização do projeto. Um grupo de cinco questões, com aferição através de escala Lickert de cinco pontos, fora destinado a cada uma das temáticas, que versaram sobre a seleção da informação, gestão do tempo, trabalho em equipe e construção de argumentos para as arguições nos diversos pontos de controle, conforme sugerido pelo Guia da BIE (2008).

No que tange a questão da seleção das informações para a realização das etapas de projeto, pôde-se averiguar que houveram dificuldades na montagem de uma estratégia para a procura das informações. No entanto, os alunos revelaram proficiência na busca de diversas fontes de pesquisa e estimulo a análise de diversas perspectivas para um mesmo conteúdo, apontando segurança para selecionar e organizar ideias, como também estabelecer relações entre os dados de mesmo teor.

Haja vista a necessidade de apresentação de um produto ao fim das atividades, as indagações do inquérito revelaram a preocupação dos alunos sobre a construção e disposição dos argumentos de forma clara, convincente, objetiva e original, visando dar segurança ao momento da explanação. Por fim, as respostas ao questionaram mostram que os membros da equipe dividiram o trabalho para todos os membros, o que contribuiu para a mediação de conflitos e inclusão de todos ao projeto.

4 Conclusões

Para Moran (2015), uma ressignificação do papel do professor é necessária, migrando de uma postura expositiva e engessada para um perfil de curador, conduzindo os alunos na escolha das informações realmente relevantes ao tema pesquisado, como também adentrar em uma perspectiva onde o professor se porte como o orientador e gerenciador das atividades.

Como consequência dessa atitude docente, os estudantes, antes imóveis, quietos, calados, agora foram instigados a buscar informações e construírem soluções para o projeto proposto, evidenciando assim o espírito de exploração. Atualmente, essa tarefa é facilitada dada a contribuição das Tecnologias de Informação e Comunicação na coleta de conteúdos sobre um tema proposto.

Em uma sequência didática onde se utiliza a aprendizagem baseada em projetos, espera-se que os estudantes interajam com o conteúdo em estudo "ouvindo, falando, perguntando, discutindo, fazendo e ensinando" (Barbosa & Moura, 2013, p.55). Desse modo, o estudante é levado a realizar "habilidades mentais de ordem superior em lugar de memorizar dados em contextos isolados, sem conexão" (Galeana, 2006, p.3).

Ao utilizarmos o modelo de Dym et al. (2010) como norteador das atividades em projetos, constatamos importantes contribuições. A primeira delas diz respeito a forma como os estudantes se debruçaram para transformar o problema declarado em uma questão da engenharia, onde a formatação das soluções fora construída de forma evolutiva, na medida em que as fases do projeto foram sendo executadas. Materializar todas as ideias em um projeto conceitual mostrou-se fundamental para que o projeto não viesse a ter mudanças bruscas no momento da elaboração dos protótipos.

Como as definições de projeto concentraram-se antes de qualquer tentativa de montagem física do produto, o momento da realização dos testes na fase do projeto preliminar (protótipos) serviu para que ajustes pudessem ser feitos, buscando uma melhor precisão no funcionamento do produto. Dos ensaios a fase do projeto detalhado, percebe-se o incremento de definições que dizem respeito a dimensão estética e de design do equipamento, exaltando a criatividade e originalidade na apresentação dos mesmos.

Nos relatos colhidos sobre a experiência em aprendizagem ativa, os estudantes, de maneira geral, apontaram como principal dificuldade o fato da disciplina estar sendo desenvolvida em momento paralelo as demais disciplinas do curso de engenharia elétrica, o que dificulta o direcionar das atenções para o desenvolvimento da melhor solução para o problema proposto.

A realização de habilidades mentais superiores, como a análise, síntese e avaliação, possibilitou que os estudantes viessem a refletir e criticar as decisões tomadas durante o percurso de construção do projeto, uma vez que as atividades "ocupam o aluno em fazer alguma coisa e, ao mesmo tempo, o leva a pensar sobre as coisas que está fazendo" (Bonwell; Eison, 1991; Silberman, 1996 as cited in Barbosa & Moura, 2014, p. 111).

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Application of a digital factory in an Industrial Engineering program aiming at the development of higher order thinking skills

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Abstract

With technological advances in the industry and the increase in the competitiveness of the market the implementations proposed by industrial engineers cannot bring uncertainty or damages to the organizations. In this context, strategies and teaching methods also need to be adapted to this new reality. This paper presents an active learning strategy that consists in the use of a digital factory in order that the student of industrial engineering can diagnose the performance of a factory in different scenarios and layouts. With this strategy, the student evaluates different problematic situations that are present in the organizations, proposes solutions that identify when a layout presents advantage and solutions that are not necessarily contemplated in the digital factory. In the planning of the strategy it was necessary to consider a theoretical framework that relies on the construction of a digital factory using computational simulators, theoretical contents aimed at the Toyota Production System and the Bloom's Taxonomy. The strategy was applied in the Production Systems course to 28 students of the undergraduate program of Industrial Engineering of the University of Caxias do Sul. The results of this application showed that the use of the digital factory aided in the development of higher order thinking skills. More studies are under way to investigate if the strategy can be considered a didactic material with potential for the promotion of meaningful learning by Industrial Engineering students. The digital factory and its application here presented were developed in the last two semesters of the Industrial Engineering program, as part of a student's senior project.

Keywords: Industrial Engineering. Bloom's Taxonomy; Digital Factory; Production Systems.

Aplicação de uma fábrica digital em um curso de Engenharia de Produção visando o desenvolvimento de habilidades de pensamento de ordem superior

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Resumo

Com os avanços tecnológicos na indústria e o aumento da competitividade do mercado, as implementações propostas por engenheiros de produção não podem trazer incerteza ou prejuízos às organizações. Nesse contexto, estratégias e métodos de ensino também precisam ser adaptados a essa nova realidade. Este artigo apresenta uma estratégia de aprendizagem ativa que consiste no uso de uma fábrica digital para que o estudante de engenharia de produção possa diagnosticar o desempenho de uma fábrica em diferentes cenários e layouts. Com este estratégia, o aluno avalia diferentes situações problemáticas que estão presentes nas organizações, propõe soluções que se identificam quando um layout apresenta vantagem e soluções que não são necessariamente contempladas na fábrica digital. No planejamento da estratégia, foi necessário considerar uma estrutura teórica que se baseie na construção de uma fábrica digital usando simuladores computacionais, conteúdos teóricos voltados para o Sistema de Produção Toyota e para a Taxonomia da Bloom. A estratégia foi aplicada no curso Sistemas de Produção a 28 alunos do curso de graduação em Engenharia de Produção da Universidade de Caxias do Sul. Os resultados desta aplicação mostraram que o uso da fábrica digital ajudou no desenvolvimento de habilidades de pensamento de ordem superior. Mais estudos estão em andamento para investigar se a estratégia pode ser considerada um material didático com potencial para a promoção de uma aprendizagem significativa por estudantes de Engenharia de Produção. A fábrica digital e sua aplicação aqui apresentada foram desenvolvidas nos últimos dois semestres do curso de graduação em Engenharia de Produção, como parte do trabalho de final de curso de um estudante.

Palavras-Chave: Engenharia de Produção; Taxionomia de Bloom; Fábrica Digital; Sistemas de Produção.

1 Introdução

Atualmente, devido à globalização e ao aumento sem precedentes na competitividade do mercado, a indústria de manufatura tem sido marcada por avanços tecnológicos muito rápidos. Segundo Hauge e Riedel (2012), isso resulta em produtos manufaturados cada vez mais personalizados, complexos e com ciclos de vida mais curtos, aumentando assim o custo marginal por produto. Nesse cenário, as organizações são confrontadas com o desafio de ajustar continuamente suas capacidades e máquinas, exigindo um alto grau de flexibilidade em ambientes dinâmicos. Nessa perspectiva, as implementações propostas por engenheiros de produção não podem trazer incerteza ou prejuízos para as organizações, e dessa forma, espaços não são abertos para a implementação de processos, que com suas mudanças venham a trazer impactos desconhecidos. Assim, os novos engenheiros acabam por reproduzir as mesmas ações estabelecidas, que lhes trazem certo comodismo e lhes afasta o interesse em aprofundar conhecimentos teóricos, uma vez que não conseguem vivenciar a mudança da prática por meio das teorias inovadoras aprendidas em seus cursos de graduação.

Nesse contexto, volta-se o olhar para os cursos de graduação de Engenharia e constata-se que as estratégias e os métodos de ensino também precisam ser adequados a essa nova realidade globalizada, pois se não houver inovação nos processos de ensino e aprendizagem, dificilmente, o novo profissional ousará inovar no ambiente de trabalho. Muitas escolas de Engenharia têm desencadeado processos de profunda transformação em seus ambientes educacionais, pois seus educadores se conscientizaram de que a prática pedagógica tem de estar voltada para a construção de conhecimentos (Graaff & Kolmos, 2007; Lima, Carvalho, Flores, & Hattum-Janssen, 2007; Lamancusa, Zayas, Soyster, Morell, & Jorgensen, 2008; Balthazar & Silva, 2010; Felder & Brent, 2010; Freeman *et al.*, 2014; Goldberg & Somerville, 2014). Caso contrário, a educação perde seu foco e até o sentido para alguns estudantes. Para tanto, a criação de ambientes de aprendizagem, onde o estudante é o sujeito do processo e está envolvido com estratégias e métodos de aprendizagem ativa, pode ser uma alternativa viável para romper com o ensino predominantemente tradicional.

Em cursos de Engenharia, é mandatório que os estudantes construam seus conhecimentos em ambientes que apresentem situações problemáticas reais da Engenharia. Com isso, estes estudantes estarão desenvolvendo as habilidades que o mundo do trabalho demanda. No caso particular da Engenharia de Produção, o interesse em fabricação inteligente e em planejamento automático de processos, apoiados por novas tecnologias e padrões (por exemplo, padrões de interoperabilidade de máquinas) estimularam a pesquisa e os desenvolvimentos educacionais (Davis et al., 2015). Dentre os desenvolvimentos educacionais, a fábrica de digital tem sido utilizada para apresentar aos estudantes os sistemas produtivos manufatureiros, bem como para apoiar a compreensão mecanicista dos processos de fabricação e desempenho do processo, além de familiarizar os estudantes com a aplicação de diferentes tecnologias e abordagens de monitoramento e análise (Mirkouei, Bhinge, McCoy, Haapala, & Dornfeld, 2016). Chwif e Medina (2015) apresentam a simulação como sendo um modelo que consegue capturar, com mais fidelidade, as características de um ambiente real de trabalho, como a dinâmica (que pode mudar seu estado ao longo do tempo) e sua natureza aleatória (que pode apresentar variáveis que sofrem alteração), podendo fazer com que se analise todos os aspectos do sistema que sejam do interesse do usuário. Assim, uma fábrica de digital constituída por um ambiente que traga em sua essência o que o mercado de trabalho oferece, além de abordagens teóricas e práticas, pode ser utilizada de maneira educacional, estabelecida para fins pedagógicos, uma vez, que nesta linha de pensamento a prática é compreendida como experimento da teoria, ou seja, o momento onde se testa o que se estudou.

O presente artigo apresenta parte dos resultados de um trabalho de conclusão do curso de Engenharia de Produção, da Universidade de Caxias do Sul, e aborda a aplicação de um instrumento virtual de aprendizagem ativa (IVAA) no qual, através do uso da simulação, o estudante de Engenharia de Produção vivencia uma nova experiência que pode lhe proporcionar o desenvolvimento de habilidades de pensamento de ordem superior, e lhe permite diagnosticar o desempenho de uma fábrica em diferentes cenários e layouts.

2 Referencial Teórico

Para Rodrigues da Silva (2010), a formação dos engenheiros na maioria das escolas brasileiras tem se encontrado sobre grande pressão quanto à necessidade de mudança, uma vez que o ensino de Engenharia, ainda hoje, envolve basicamente aulas expositivas dentro das salas de aula, seguidas de resolução de exercícios para que os estudantes adquiram apenas as habilidades necessárias para conseguirem aprovação em testes. Segundo Graaff e Christensen (2004), a aprendizagem ativa e a educação em Engenharia constituem um par natural. Ainda segundo esses autores, o engenheiro deve ser educado para projetar e construir soluções para problemas do mundo real. Assim, o estudante de Engenharia tem de ser educado para desenvolver competências, e para isso ele tem de ser o principal ator do processo, com o professor atuando como mediador desse processo. Isso pressupõe uma aprendizagem que envolva cognitivamente o estudante em um ambiente desafiador, ativo e colaborativo em vez de um ambiente de passividade, de atividades mecânicas como copiar e assistir aulas (Bonwell & Eison, 1991; Felder & Brent, 2009). A criação de ferramentas e do ambiente de aprendizagem são funções do professor, ou seja, sua atenção é colocada no desenvolvimento das habilidades e das habilidades conceituais, atitudinais e procedimentais dos estudantes, criando condições para o desenvolvimento cognitivo em níveis mais avançados, como análise, síntese e criação (Ferraz & Belhot, 2010).

2.1 A Taxionomia de Bloom

Muitas vezes, os professores se esquecem que, para se adquirir altos graus de abstração, é mais fácil partir dos conceitos mais simples para os mais complexos, isto é, para desenvolver uma nova habilidade, o estudante deve ter desenvolvido, anteriormente, habilidades menos complexas. No ensino de Engenharia, é comum se esperar dos estudantes a habilidade de abstração nas atividades acadêmicas, em particular em um ambiente de simulação. Contudo, observa-se que uma parte muito pequena dos estudantes conseguem realizar atividades de abstração de forma satisfatória. Um instrumento que pode ser utilizado para auxiliar no desenvolvimento das habilidades nos cursos de engenharia é a Taxionomia Bloom, uma vez que esta tem como objetivo ajudar no planejamento, organização e controle dos objetivos de aprendizagem (Ferraz & Belhot, 2010). Ainda segundo estes autores, "A definição clara e estruturada dos objetivos instrucionais, considerando a aquisição de conhecimento e de competências adequados ao perfil profissional a ser formado direcionará o processo de ensino para a escolha adequada de estratégias, métodos, delimitação do conteúdo específico, instrumentos de avaliação e, consequentemente, para uma aprendizagem efetiva e duradoura".

Embora Bloom e seus colaboradores tenham explorado amplamente os domínios cognitivo, afetivo e psicomotor, o domínio cognitivo acabou por ser o mais conhecido e utilizado. Educadores de diferentes áreas, e também da Engenharia, se baseiam nos pressupostos teóricos do domínio cognitivo para definirem, em seus planejamentos educacionais, objetivos, estratégias e sistemas de avaliação.

A Taxionomia de Bloom tem em sua estrutura seis classes onde a mesma segue uma forma hierárquica que facilita a categorização dos objetivos educacionais, conforme pode ser observado na Figura 1.

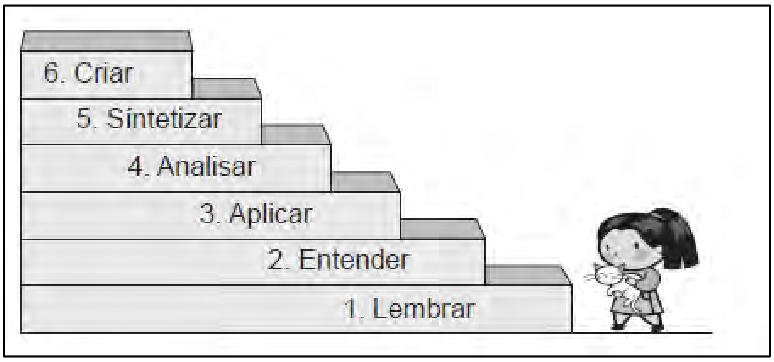


Figure 43 – Categorização atual da Taxionomia de Bloom (Fonte: Ferraz & Belhot (2010))

Neste trabalho, o planejamento de uma fábrica digital, bem como as atividades a ela relacionadas e a avaliação de sua utilização levou em conta os pressupostos da Taxionomia de Bloom

2.2 A fábrica digital

Uma fábrica digital, constituída por um ambiente que traga em sua essência o que o mercado de trabalho oferece, além de abordagens teóricas e prática, pode ser utilizada de maneira educacional para simular possíveis comportamentos dentro de uma dinâmica com base educacional estabelecida para fins pedagógicos, uma vez que nesta linha de pensamento a prática é compreendida como experimento da teoria, ou seja, o momento onde se testa o que se estudou (Satolo, 2011; Haghighi, Zadeh, Sivard, Lundholm, & Eriksson, 2014).

Satolo (2011) propõe a simulação de processos produtivos associados ao uso didático como uma ferramenta de apoio ao estudante de Engenharia de Produção, sendo considerada uma forma pedagógica eficiente para o ensino, permitindo que as estratégias sejam compreendidas pelo indivíduo estando próximo a um ambiente que simule a realidade. Para Roveri (2004), a simulação colabora para a construção do conhecimento através de experiências significativas, pois é uma ferramenta que proporciona um reforço no sentir e no fazer dos estudantes, em confronto predominante com o observar e pensar, pois o aprendizado resulta das experiências significativas, do envolvimento psicológico e da autonomia com o próprio processo de aprendizagem. Satolo (2011) cita que a utilização da simulação para uso didático visa trabalhar os conceitos que são ensinados durante a vida acadêmica do estudante, como por exemplo: lotes de produção, padronização de trabalho, formação de células de manufatura, redução de tempo de atravessamento, diminuição de transporte; atividades que agregam e não agregam valor.

3 Criação e Aplicação de um Instrumento Virtual de Aprendizagem Ativa

A ideia de pesquisar e demonstrar a validade de um laboratório dentro de um curso de Engenharia de Produção surgiu de uma prática vivenciada em um laboratório de simulação real localizado em uma empresa no interior de São Paulo. Esta prática despertou o interesse do autor em buscar por um referencial teórico que desse sustentação para a percepção e importância da criação de um ambiente de simulação com cunho pedagógico voltado para estudantes de Engenharia de Produção, onde o embasamento de um referencial pedagógico mostrou-se de grande importância.

Limitações de recursos financeiros levaram à não criação de um ambiente de simulação real, mas sim virtual. Este ambiente, uma fábrica digital, foi denominado Instrumento Virtual de Aprendizagem Ativa (IVAA) e tem como principal objetivo a navegação do estudante em um cenário que simula uma empresa real proporcionando o desenvolvimento de habilidades de pensamento de ordem superior e permitindo diagnosticar o desempenho de uma fábrica em diferentes cenários e layouts.

O IVAA foi aplicado na disciplina de Sistemas de Produção para 28 estudantes do curso de Engenharia de Produção, com o objetivo de aplicar diversos conteúdos tratados na disciplina, procurando então, aprimorar a aprendizagem. Os estudantes navegaram pelo ambiente digital, para se familiarizarem e testarem a dinâmica proposta neste trabalho, conforme ilustrado na Figura 2.

Durante a realização da dinâmica, o orientador do ambiente acompanhou a navegação para auxiliar os estudantes nas dificuldades e, se necessário, propor uma nova navegação, caso algum estudante, não estivesse conseguindo avançar (Figura 3).

Figura 2. Navegação inicial no IVAA (Fonte: Autor (2017))

Figura 3. Aplicação do Instrumento Virtual de Aprendizagem Ativa com acompanhamento do Facilitador (Fonte: Autor (2017))

Antes de iniciar a aplicação do instrumento foi apresentado aos estudantes o instrumento propriamente dito, qual atividade estaria sendo realizada e o seu principal objetivo. Em seguida, os estudantes foram introduzidos ao software ProModel© que Harrel, Mott, Bateman, Bowden e Gogg (2002) descrevem como um programa que utiliza uma construção que permite criações estruturadas de um ambiente de simulação. Na sequência, uma primeira simulação foi apresentada aos estudantes para que eles se familiarizassem com a estrutura da fábrica digital, quantidade de colaboradores, nome de máquinas, tempo de processos e também a identificar o tempo de realização da simulação preenchendo um registro relativo ao IVAA.

Dando sequência na atividade, o professor realizou uma explanação teórica sobre os tipos de layout que podem estar presentes em um ambiente fabril, bem como o conceito de *lead time*. Para potencializar a aprendizagem baseada na prática, solicitou-se aos estudantes uma nova rodada no ambiente digital para que identificassem quais os tipos de layout são adotados pelas fábricas digitais conforme ilustrado nas Figuras 4 e 5 com suas respectivas características.

Figura 4 - Fábrica digital com um modelo por processo (Fonte: Autor (2017)).

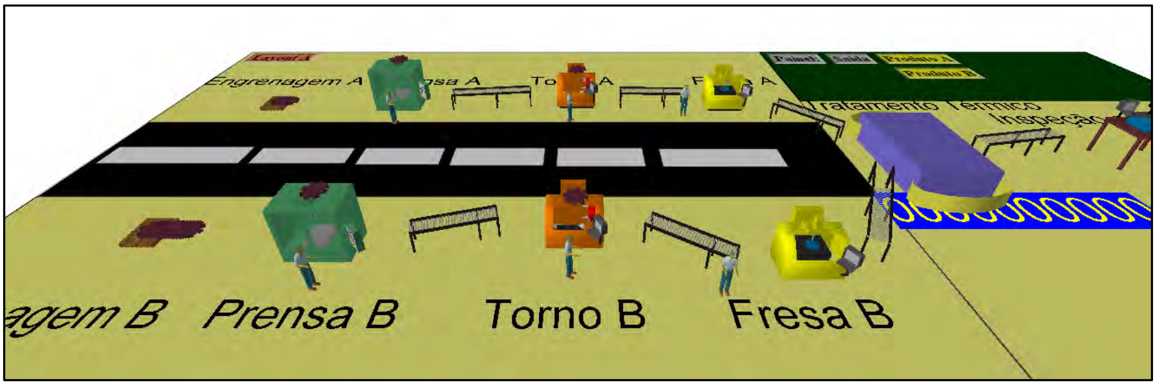


Figura 5 - Fábrica digital com um modelo por produto (Fonte: Autor (2017)).

Os estudantes também analisaram do início da produção até a entrega do produto identificando a composição do *lead time*, como por exemplo: processamento, transporte e inspeção. Neste ponto, o estudante pôde observar que quanto menor for o tempo de espera, processamento, inspeção e transporte menor vai ser o custo produtivo desta fábrica.

Finalizando esta etapa inicial, realizou-se uma interação com os estudantes, para verificação o nível de compreensão do processo, onde o professor incentivou os estudantes de forma oral a apresentarem, sob seu ponto de vista, quais características foram preenchidas no registro do IVAA. A estratégia neste momento era verificar se a experimentação do modelo digital, próximo do real, estava sendo capaz de potencializar a aprendizagem, e se estava auxiliando a desenvolver as habilidades necessárias para a próxima etapa. Além disso, este foi um momento de socialização, interação e cooperação entre os estudantes.

Com o avanço destas etapas, e o aumento da dificuldade, tornou-se necessário que os estudantes manipulassem as quantidades de chegada dos produtos na fábrica digital. Nesta etapa das atividades, a coleta de dados foi separada, um estudante coletou informações sobre o layout A e outro sobre o layout B. Abriu-se espaço, então, para cada estudante responder o registro de forma individual, e fazer suas respectivas análises, bem como para debater com o colega da dupla, e para avaliarem questões que necessitassem verificar em qual ponto acontece vantagem para o layout A bem como para o layout B.

Buscou-se instigar o estudante a responder questões com base em informações obtidas através dos dados capturados no simulador, mostrando se a vivência na fábrica digital levou ao desenvolvimento de habilidades de ordem superior através da simulação. De forma paralela às simulações, o ensinamento teórico potencializado pelo professor faz com que o estudante se torna apto a conhecer uma fábrica podendo então identificar problemas, oportunidades e características da mesma. Por fim foi solicitado aos estudantes que apresentem seus diagnósticos da fábrica digital, bem como o seu ponto de vista sobre a situação das fábricas digitais. Este ponto foi de muita importância para o professor, pois observou se houve compreensão dos conceitos de forma clara, precisa e diferenciada sem ter o risco de obtenção de respostas mecanicamente memorizadas como avaliações tradicionais.

Os registros do IVVA foram desenvolvidos de forma que conduzissem o estudante à reflexão dos diferentes cenários digitais simulados. De fato, a estratégia é que o estudante visualizasse, analisasse, fizesse interações e fizesse registros dos principais indicadores nos dois diferentes cenários simulados. Com base nos conceitos teóricos e na prática virtual realizada, o estudante desenvolveu a capacidade crítica de análise de forma que conseguiu compreender as melhorias de um cenário para outro. Neste sentido, por meio das evidências compreendidas nas etapas anteriores, foi possível que os estudantes se tornassem aptos a responder a última etapa do registro do IVAA.

Ao finalizar foi proposto um debate coletivo com os estudantes, mediado pelo professor, estimulando a socialização entre o mesmo. Dessa forma, os estudantes puderam compartilhar suas análises, dificuldades e a suas visões sobre os cenários simulados. Neste ponto, foi proposto aos estudantes criar um novo modelo de produção que venha atender as necessidades da fábrica digital de uma forma mais eficiente do que as apresentadas durante a dinâmica, pois através destes diagnósticos os mesmos mostraram ter aptidão para corrigir problemas que foram encontrados nos dois modelos apresentados inicialmente.

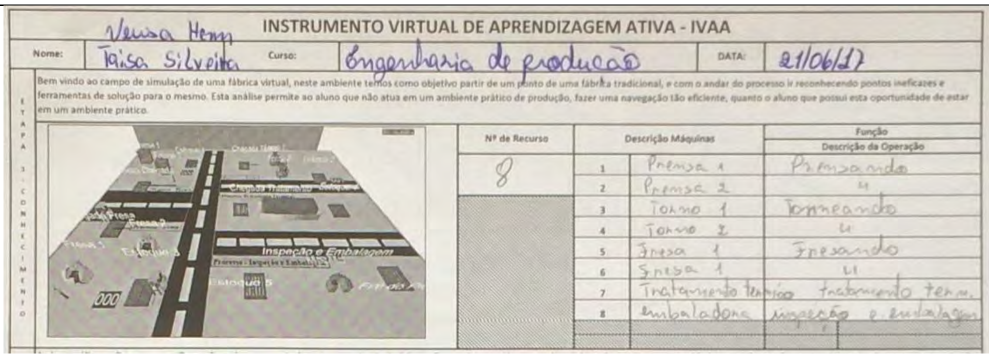
4 Resultados e Discussão

Os registros do IVAA foram estruturados em etapas de acordo com cinco das categorias do domínio cognitivo da Taxionomia proposta por Bloom: lembrar, entender, aplicar, analisar, sintetizar e avaliar (Ferraz & Belhot, 2010). A categoria “criar” não foi contemplada no planejamento do IVAA.

Na Tabela 1, está apresentado um exemplo do registro do IVAA, bem como podem ser verificados os registros efetuados por uma dupla de estudantes para cada uma das etapas.

Os estudantes foram provocados a entender a teoria para explicar a vivência na simulação, o que, para Moreira e Masini (2006), evidencia a compreensão significativa do assunto sob estudo, uma vez que utiliza situações problemas não familiares para aprimorar conhecimentos existentes.

Tabela 23. Exemplo de registro do IVAA por uma dupla de estudantes (Fonte: Autor (2017)).

L E M B R A R	
	Etapa 1: Nesta etapa tem objetivo de contextualização com os conteúdos previamente desenvolvidos na disciplina, como fluxo contínuo e sua importância, estoque em processo, capacidade, etc.

INSTRUMENTO VIRTUAL DE APRENDIZAGEM ATIVA - IVAA

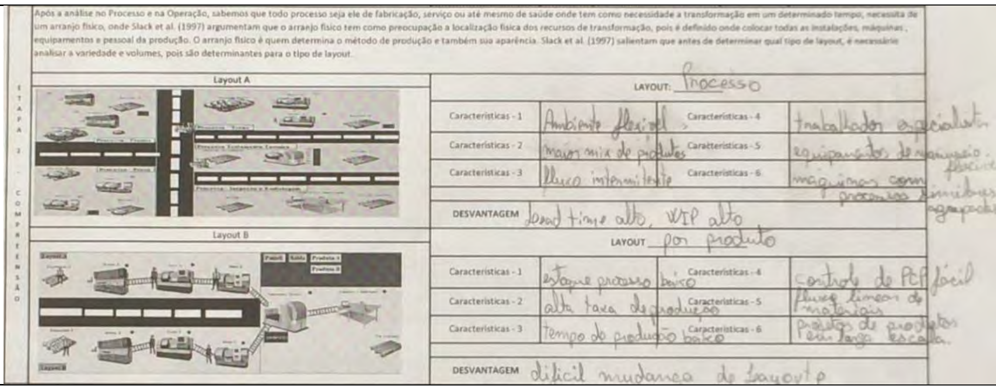
Nome: Neusa Henn / Taisa Silveira Curso: Engenharia de produção DATA: 21/06/17

ETAPA 1 - CONHECIMENTO

Bem vindo ao campo de simulação de uma fábrica virtual, neste ambiente temos como objetivo partir de um ponto de uma fábrica tradicional, e com o andar do processo ir reconhecendo pontos ineficazes e ferramentas de solução para o mesmo. Esta análise permite ao aluno que não atua em um ambiente prático de produção, fazer uma navegação tão eficiente, quanto o aluno que possui esta oportunidade de estar em um ambiente prático.

Nº de Recurso	Descrição Máquinas		Função – Descrição da Operação
8	1	Prensa 1	Prensando
	2	Prensa 2	"
	3	Torno 1	Torneando
	4	Torno 2	"
	5	Fresa 1	Fresando
	6	Fresa 1	"
	7	Tratamento térmico	tratamento term.
	8	embaladora	inspeção e embalagem

ENTENDER



Após a análise no Processo e na Operação, sabemos que todo processo seja ele de fabricação, serviço ou até mesmo de saúde onde tem como necessidade a transformação em um determinado tempo, necessita de um arranjo físico, onde Slack et al. (1997) argumentam que o arranjo físico tem como preocupação a localização física dos recursos de transformação, pois é definido onde colocar todas as instalações, máquinas, equipamentos e pessoal da produção. O arranjo físico é quem determina o método de produção e também sua aparência. Slack et al. (1997) salientam que antes de determinar qual tipo de layout, é necessário analisar a variedade e volumes, pois são determinantes para o tipo de layout.

Layout A — LAYOUT: Processo

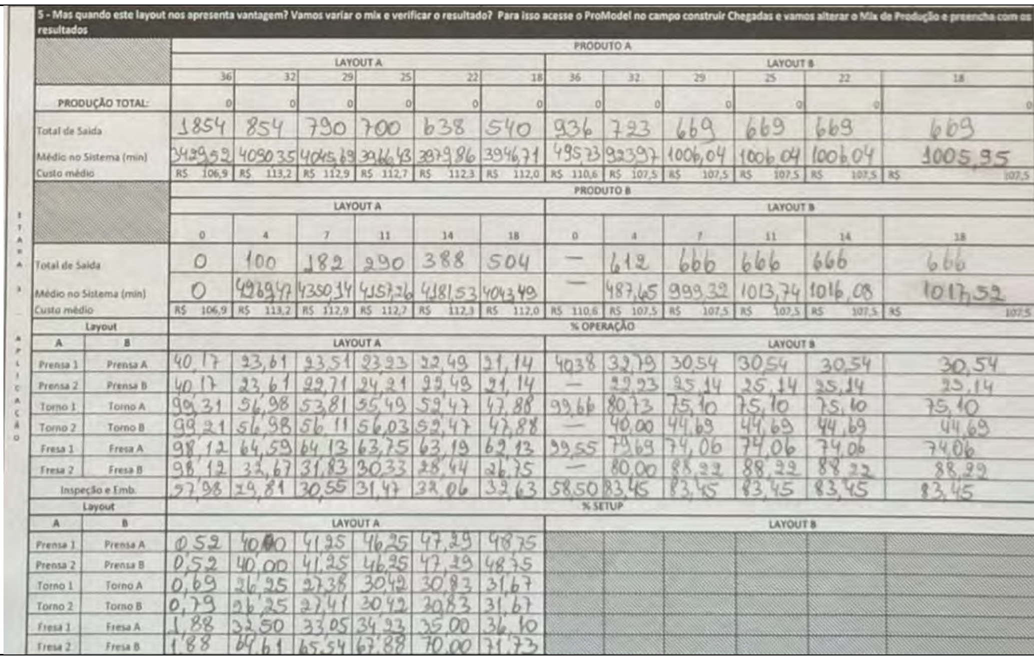
Características - 1	Ambiente flexível	Características - 4	trabalhador especialista
Características - 2	maior mix de produtos	Características - 5	equipamentos de [illegible]
Características - 3	fluxo intermitente	Características - 6	máquinas com processos similares agrupados
DESVANTAGEM	lead time alto, WIP alto		

Layout B — LAYOUT: por produto

Características - 1	estoque processo baixo	Características - 4	controle de PCP fácil
Características - 2	alta taxa de produção	Características - 5	fluxo linear de materiais
Características - 3	tempo do produto baixo	Características - 6	produtos de produtos em larga escala
DESVANTAGEM	difícil mudança de layout		

Etapa 2: O estudante ao realizar a navegação nas fábricas digitais desenvolve a habilidade para caracterizar os diferentes tipos de layout que compõem o ambiente. Assim, há uma contrução significativa com a empresas reais.

APLICAR



5 - Mas quando este layout nos apresenta vantagem? Vamos variar o mix e verificar o resultado? Para isso acesse o ProModel no campo construir Chegadas e vamos alterar o Mix de Produção e preencha com os resultados

PRODUTO A	Layout A 36	Layout A 32	Layout A 29	Layout A 25	Layout A 22	Layout A 18	Layout B 36	Layout B 32	Layout B 29	Layout B 25	Layout B 22	Layout B 18
PRODUÇÃO TOTAL:	0	0	0	0	0	0	0	0	0	0	0	0
Total de Saída	1854	854	790	700	638	540	936	723	669	669	669	669
Médio no Sistema (min)	3429,52	4090,35	4045,69	3966,43	3979,86	3946,71	495,73	923,97	1006,04	1006,04	1006,04	1005,95
Custo médio	R$ 106,9	R$ 113,2	R$ 112,9	R$ 112,7	R$ 112,3	R$ 112,0	R$ 110,6	R$ 107,5	R$ 107,5	R$ 107,5	R$ 107,5	R$ 107,5

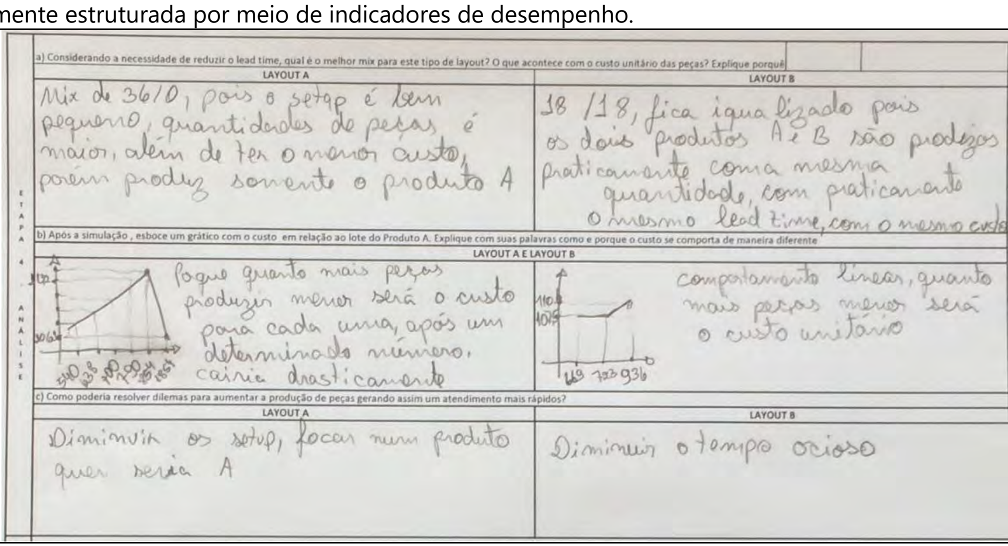
PRODUTO B	Layout A 0	Layout A 4	Layout A 7	Layout A 11	Layout A 14	Layout A 18	Layout B 0	Layout B 4	Layout B 7	Layout B 11	Layout B 14	Layout B 18
Total de Saída	0	100	182	290	388	504	—	612	666	666	666	666
Médio no Sistema (min)	0	4969,47	4350,14	4157,26	4181,53	4043,49	—	487,65	999,32	1013,74	1016,08	1017,52
Custo médio	R$ 106,9	R$ 113,2	R$ 112,9	R$ 112,7	R$ 112,3	R$ 112,0	R$ 110,6	R$ 107,5	R$ 107,5	R$ 107,5	R$ 107,5	R$ 107,5

Layout A	Layout B	% OPERAÇÃO Layout A						Layout B					
Prensa 1	Prensa A	40,17	23,61	23,51	23,23	22,49	21,14	40,38	32,79	30,54	30,54	30,54	30,54
Prensa 2	Prensa B	40,17	23,61	22,71	24,21	22,49	21,14	—	22,23	25,14	25,14	25,14	25,14
Torno 1	Torno A	99,31	56,98	53,81	55,49	52,47	47,88	99,66	80,73	75,10	75,10	75,10	75,10
Torno 2	Torno B	99,21	56,98	56,11	56,03	52,47	47,88	—	40,00	44,69	44,69	44,69	44,69
Fresa 1	Fresa A	98,12	64,59	64,13	63,75	63,19	62,13	99,55	79,69	74,06	74,06	74,06	74,06
Fresa 2	Fresa B	98,12	32,67	31,83	30,33	28,44	26,75	—	80,00	88,22	88,22	88,22	88,22
Inspeção e Emb.		27,98	19,81	30,55	31,47	32,06	32,63	58,50	83,45	83,45	83,45	83,45	83,45

Layout A	Layout B	% SETUP Layout A						Layout B
Prensa 1	Prensa A	0,52	40,00	41,25	46,25	47,29	48,75	
Prensa 2	Prensa B	0,52	40,00	41,25	46,25	47,29	48,75	
Torno 1	Torno A	0,69	26,25	27,36	30,42	30,83	31,67	
Torno 2	Torno B	0,79	26,25	27,41	30,42	30,83	31,67	
Fresa 1	Fresa A	1,88	32,50	33,05	34,23	35,00	36,10	
Fresa 2	Fresa B	1,88	64,61	65,54	67,88	70,00	71,73	

Etapa 3: O estudante, por meio da simulação da fábrica digital, consegue obter indicadores de perforamance dos dois diferentes cenários simulados (lauout A e layout B). A simulação foi configurada para prever um futuro período de 160 horas, aproximadamente um mês de trabalho em um turno. Nesta etapa, aprendizagem é fortemente estruturada por meio de indicadores de desempenho.

ANÁLISAR



a) Considerando a necessidade de reduzir o lead time, qual é o melhor mix para este tipo de layout? O que acontece com o custo unitário das peças? Explique porquê

LAYOUT A: Mix de 36/0, pois o setup é bem pequeno, quantidades de peças é maior, além de ter o menor custo, porém produz somente o produto A

LAYOUT B: 18/18, fica igualizado pois os dois produtos A e B são produzidos praticamente com a mesma quantidade, com praticamente o mesmo lead time, com o mesmo custo

b) Após a simulação, esboce um gráfico com o custo em relação ao lote do Produto A. Explique com suas palavras como e porque o custo se comporta de maneira diferente

LAYOUT A E LAYOUT B

Porque quanto mais peças produzir menor será o custo para cada uma, após um determinado número, cairia drasticamente

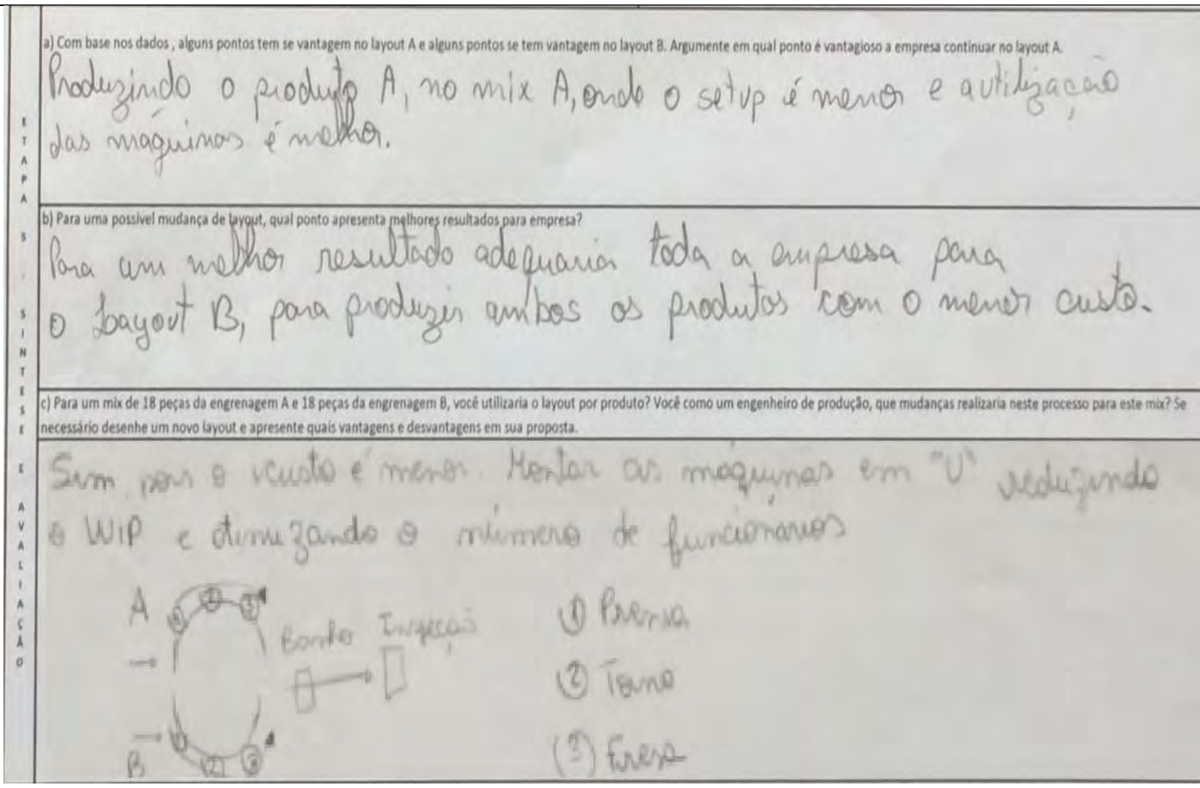
comportamento linear, quanto mais peças menor será o custo unitário

c) Como poderia resolver dilemas para aumentar a produção de peças gerando assim um atendimento mais rápidos?

LAYOUT A: Diminuir os setup, focar num produto que seria A

LAYOUT B: Diminuir o tempo ocioso

Etapa 4: Com base nos indicadores de desempenho obtidos na etapa anterior, o estudante foi capaz de realizar a análise comparativas dos ambientes de simulados. Além disso, a socialização com o colega permitiu aprendizagem compartilhada por meio da interação com o colega.

SINTETISAR E AVALIAR	
	Etapa 5: O estudante foi capaz de reunir as diversar informações comparando o layout A com o layout B e por fim criar uma nova sugestão de melhoria, avaliando com as propostas apresentadas no início da dinamica.

Da análise dos dados de preenchimento dos registros foi possível verificar que mais de 70% dos estudantes desenvolveram as habilidades de pensamento de ordem superior, isto é, os estudantes foram capazes de lembrar, entender, aplicar, analisar, sintetizar e avaliar conhecimentos relativos ao desempenho de uma fábrica em diferentes cenários e layouts, inclusive chegando ao estágio de criação de um novo modelo de fábrica, ou seja, os estudantes criaram novas sugestões de melhoria, atingindo assim a categoria "criar", que não havia sido contemplada no planejamento do IVAA.

5 Considerações Finais

Para Dettmer (2001), um ambiente acadêmico onde o estudante não fica próximo de uma fábrica real, permite apenas que o estudante esteja sujeito a conhecer as ferramentas que vão poder auxiliá-lo no mundo profissional. Entretanto, se o estudante estiver em contato com seu objeto de estudo (um laboratório que simula os contextos de atuação de um engenheiro de produção), o mesmo terá uma visão sistematizada de todos os processos permitindo então aplicar a ferramenta aprendida.

As estratégias de aprendizagem são de grande importância no processo de ensino e aprendizagem de um engenheiro de produção, uma vez que este estuda para conhecer e entender os pontos de um sistema industrial, e, portanto, necessita também conhecer técnicas de aprendizagem que possam ser aplicadas no seu âmbito de trabalho. Ao se criar uma fábrica digital dentro de um ambiente de simulação buscou-se a construção de um modelo educacional que permitisse aos estudantes de Engenharia de Produção utilizá-lo, de modo que atingissem o desenvolvimento de habilidades de pensamento de ordem superior do estudante e permitisse diagnosticar o desempenho de uma fábrica em diferentes cenários e layouts.

A utilização da Taxionomia de Bloom no planejamento das atividades e do sistema de avaliação da fábrica digital aqui apresentada, conduziu os estudantes de Engenharia de Produção ao desenvolvimento das habilidades de pensamento de ordem superior. Posto de outra forma, os estudantes atingiram os mais altos graus de abstração do conteúdo em questão, partindo dos conceitos mais simples para os mais elaborados.

A concepção desta fábrica digital cria oportunidades para novos ambientes de aprendizagem no curso de Engenharia de Produção da Universidade de Caxias do Sul. Outros conceitos importantes e problemas reais das disciplinas que se ocupam de um ambiente industrial podem se beneficiar da criação deste IVAA. Além disso, este IVAA pode ser utilizado para apresentar aos ingressantes do curso, quais atividades podem ser realizadas por um engenheiro de produção no ambiente em que o mesmo vai atuar, engajando estes estudantes em seus processos de aprendizagem e lhes proporcionando uma melhor formação.

Para conceber o IVAA, foi necessário que o autor buscasse um aprofundamento teórico sobre a utilização da simulação computacional e sobre teorias de aprendizagem, que o estimulou a refletir sobre o seu desenvolvimento como profissional da Engenharia, compreendendo, de modo significativo, a teoria adquirida, e as habilidades conceituais, procedimentais e atitudinais desenvolvidas durante sua vivência no ambiente acadêmico.

Em uma próxima aplicação da fábrica digital, pretende-se conceber uma sequência didática na qual se utilizará a fábrica digital em várias etapas da sequência, iniciando-se com um levantamento dos conhecimentos prévios dos estudantes, para no decorrer e ao final da aplicação da sequência didática se buscar evidências da ocorrência de uma aprendizagem significativa por parte dos estudantes.

Finalmente, tem-se de ressaltar a importância da utilização da simulação em ambientes digitais nas implementações propostas por engenheiros de produção, pois esta pode diminuir possíveis prejuízos para as organizações, bem como impactos desconhecidos e indesejáveis em um cenário globalizado e de altíssima competitividade de mercado.

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Project Based Learning: A Comparison between the Traditional and Agile Methods in Engineering Discipline.

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Abstract

The Production System Project 5 (PSP5) discipline is part of the Production Engineering course at the University of Brasília (UnB) and adopts an active methodology through PBL (*Project Based Learning*) since 2013. Each team is responsible for project with the intention of solving a real problem exposed by a company (public or private agency) in the scope of Production Engineering, with content related to the technical anchor discipline Quality Management. Thus, ensuring a superior performance of the final project is to ensure that the planned has been met in content, interaction, research and delivery capability of actual results. The discipline of PSP5 has always used the traditional method of projects, but during a new dynamic context in which the market is currently, the need arose to adapt to the discipline a methodology that would provide greater interactivity with the customer and attendance to delivery requirements in a timely manner. Thus, from 2015 onwards, the agile principles in the discipline were partially implemented, so that part of the teams executed projects according to agile principles and, in another part of the teams, executed the projects following the traditional principles of project management. The objective of this research is to perform a comparative analysis between the performance of the projects and students who have adopted the traditional and agile method. To reach this objective an exploratory research with quantitative approach was carried out through structural equations. A census was conducted with questionnaires to all the students who were enrolled in the discipline. The results show that the latent variables Client, Human-Time Cost, Quality, Risk and Time predict performance in traditional projects in 42.6% and in agile projects in 49.9%, demonstrating that when adopting the PBL in the discipline, the best results are presented when the method is agile.

Keywords: Project Based Learning, Traditional Project, Agile Project, Structural Equations

Project Based Learning: Uma Comparação entre o Método Tradicional e Ágil em Disciplina de Engenharia.

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Resumo

A disciplina de Projeto de Sistema de Produção 5 (PSP5) está inserida no curso de Engenharia de Produção da Universidade de Brasília (UnB) e adota metodologia ativa por meio de PBL (Project Based Learning) desde 2013. Cada equipe é responsável por realizar um projeto com o intuito de resolver um problema real exposto por uma empresa (órgão público ou privado) no âmbito da Engenharia de Produção, com conteúdo relacionado à disciplina âncora técnica Gestão da Qualidade. Assim, garantir um bom desempenho do projeto final é assegurar que o planejado foi cumprido em conteúdo, interação, pesquisa e capacidade de entrega de resultados reais. A disciplina de PSP5 sempre utilizou o método tradicional de projetos, mas em meio a um novo contexto dinâmico em que o mercado se encontra atualmente, surgiu a necessidade de adaptar à disciplina uma metodologia que proporcionasse maior interatividade com o cliente e atendimento aos requisitos de entrega em tempo hábil. Dessa forma, a partir de 2015 implementou-se parcialmente os princípios ágeis na disciplina, de forma que parte das equipes executavam projetos seguindo princípios ágeis e, outra parte dos times, executavam os projetos seguindo os princípios tradicionais de gerenciamento de projeto. O objetivo desta pesquisa é realizar uma análise comparativa entre o desempenho dos projetos e estudantes que adotaram o método tradicional e ágil. Para alcançar este objetivo foi realizada uma pesquisa exploratória com abordagem quantitativa por meio de equações estruturais. Foi realizado um censo com questionários a todos os alunos que estavam matriculados na disciplina. Os resultados encontrados explicam que as variáveis latentes Cliente, Custo Homem-Hora, Qualidade, Risco e Tempo predizem Desempenho em projetos tradicionais em 42,6% e em projetos ágeis em 49,9%, demonstrando que ao adotar o PBL na disciplina, os melhores resultados são apresentados quando o método é ágil.

Palavras-Chave: Project Based Learning, Projeto tradicional, Projeto ágil, Equações estruturais

1 Introdução

Muitos cursos têm implementado as metodologias ativas. Desde 2011, o Curso de Engenharia de Produção da Universidade de Brasília adotou a metodologia ativa via PBL (*Project Based Learning)*. Porém as opções de diferentes tipos de abordagens de projetos são decididas pelos professores das disciplinas. A abordagem tradicional de gerenciamento de projetos é utilizada na execução de projetos na disciplina de Projeto de Sistema de Produção 5 (PSP5) do curso de Engenharia de Produção da Universidade de Brasília (UnB) desde de sua primeira oferta em 2013. Em meio ao contexto dinâmico em que o mercado se encontra atualmente, surgiu a necessidade de adaptar à disciplina uma metodologia que proporcionasse maior interatividade, simplicidade, atendimento aos requisitos de entrega e que aumentasse a agilidade da gestão de projetos, uma vez que o prazo de desenvolvimento dos projetos é curto, de duração aproximada de três meses. Sendo assim, a partir de 2015 implementou-se, de forma parcial, os princípios ágeis na disciplina. Parte dos times executavam projetos seguindo princípios ágeis e, outra parte dos times, seguindo os princípios tradicionais de gerenciamento de projeto. Com o uso de dois tipos de abordagem de projetos se procurou responder: qual a melhor abordagem de projetos em metodologias ativas: tradicional ou ágil?

Espera-se que ao responder esta pergunta, haja uma mudança nas instruções para garantir um melhor aproveitamento da metodologia ativa. Assim, o presente estudo tem como objetivo realizar uma análise comparativa entre o desempenho dos projetos que foram executados de acordo com a abordagem tradicional de gerenciamento de projetos e os que foram executados seguindo a abordagem ágil de gerenciamento de projetos na disciplina PSP5. Acredita-se que o seguinte estudo possibilita dar uma opção aos alunos quanto ao tipo de projeto que desejam trabalhar, respeitando a individualidade e os diferentes perfis de aprendizagem.

2 Fundamentação teórica

2.1 Metodologia Ativa via PBL

O curso de Engenharia de Produção, da Universidade de Brasília-UnB, desde 2011 adota a aprendizagem via metodologia ativa com PBL (*Project Based Learning*). Existem 8 disciplinas de projetos (PSP,s) que estão relacionadas a disciplinas de conteúdo base. No caso desta pesquisa, foi usada como cenário a disciplina de PSP5, que serve como aplicação ativa da disciplina de Gestão da Qualidade. O processo possui algumas etapas:

1- Escolha dos participantes (clientes)

A cada semestre existe uma seleção de casos-problema a serem atendidos. Estes casos-problema, serão os clientes das equipes de alunos em sala de aula e seu contato com a Universidade se dá de duas maneiras: ativo, por meio da busca do professor da disciplina e passivo, quando as empresas entram em contato com o Curso de Engenharia de Produção, pois possuem conhecimento do tipo de trabalho realizado em anos anteriores.

2- Cronograma de trabalho

Uma vez apresentado os casos-problema e seus clientes, são divididas as equipes e elaborado um cronograma que compreenda todos "*stakeholders*" (Cliente, professor, aluno, universidade, quanto aos prazos)

3- Reuniões e aplicações

Em posse do cronograma são marcadas reuniões com os clientes e consultas com os professores, responsáveis de alinhar o escopo e retirar dúvidas. É nesta fase que se aplicam pesquisas e ferramentas da Engenharia de Produção com o intuito de resolver os problemas apresentados. Todo este processo é realizado seguindo a metodologia de projetos.

4- Entrega Final

Finalmente, após as validações com professores e clientes, o estudante elabora um documento final com os resultados.

Uma vez cumprida as quatro etapas os estudantes obtêm a nota final na disciplina. Porém nos últimos anos o crescimento de diferentes abordagens de projeto tem feito as disciplinas adotarem outras opções como os projetos ágeis. Assim, conhecer o que cada projeto pode oferecer é interessante na evolução deste tópico que contribui para o crescimento do PBL.

2.2 Gerenciamento de Projetos

O gerenciamento de projetos, segundo o PMBOK® (PMI, 2013), é definido como "a aplicação de conhecimentos, habilidades e técnicas às atividades do projeto a fim de atender aos seus requisitos. O autor Heldman (2006) defende que o gerenciamento de projetos tem a principal vantagem de poder ser aplicado a empreendimentos de qualquer magnitude, não sendo limitado a apenas propostas de alta complexidade e custo.

A abordagem tradicional foi amplamente utilizada no gerenciamento de projetos. Segundo Kerzner (2006) a abordagem tradicional de gerenciamento de projeto baseia-se no planejamento, execução e controle de atividades do projeto e delineia que o objetivo pré-estabelecido no projeto seja atingido e que os custos, prazos e escopo do mesmo sejam controlados. O autor também afirma que, devido à necessidade de definir durante a fase de planejamento quais são os limites de escopo, os prazos para cada atividade e os custos do projeto, há pouca flexibilidade nesta abordagem, tornando-se burocrática e que, sendo assim, não se pode responder de forma ágil às mudanças estruturais e ambientais que ocorrem frequentemente no meio empresarial. Sendo assim, tem-se a importância da metodologia ágil de gerenciamento de projetos. Schuh (2005) define o desenvolvimento ágil como um método de desenvolvimento de software que promove o empoderamento e a confiança das pessoas, e que reconhece a mudança como norma, promovendo feedbacks constantes às equipes de projeto.

É importante medir e analisar o desempenho do projeto a fim de verificar se o seu resultado ocorreu de forma satisfatória e, também, para identificar as variáveis que mais influenciaram o desempenho do projeto. Essas variáveis servirão de insumo para alocar de forma mais adequada os recursos limitados do projeto (Hwang & Lim, 2013). Atkinson (1999) propõe que o sucesso do projeto está relacionado às medidas de desempenho de custo, prazo e qualidade, que são denominados componentes do "triângulo de ferro". Mesmo a literatura indicando que essas variáveis podem medir o desempenho do projeto, há autores que afirmam que são insuficientes para medi-lo. Pinto e Slevin (1989) acrescentam também os critérios de eficácia e satisfação do cliente. Para Raz et al (2002), as práticas de gerenciamento de riscos também contribuem no desempenho do projeto. Segundo o PMI (2013), risco é um evento ou uma condição incerta que, se ocorrer, tem um efeito positivo ou negativo em um ou mais objetivos do projeto, como escopo, prazo, custo e qualidade. Qualidade, segundo Deming (1990), é a satisfação das necessidades do cliente em primeiro lugar. O custo do projeto compreende os gastos com os recursos necessários para execução do projeto (Hank & Golvindarajam, 1997). O impacto no cliente também é um agente importante para atingir o bom desempenho do projeto (Shenhar & Dvir, 2007).

3 Métodos

Esta pesquisa consiste em um estudo exploratório com abordagem quantitativa, pois traduz por meio de técnicas estatísticas informações a respeito das questões levantadas. Para analisar o desempenho do projeto, pesquisou-se na literatura quais seriam os indicadores adequados para medi-lo nos projetos realizados na disciplina e foram definidas cinco variáveis latentes: Qualidade, Risco, Tempo, Cliente e Custo do projeto, esse último sendo representado por Custo homem-hora, que corresponde à dedicação de cada aluno por horas trabalhadas no projeto. Como técnica de coleta de dados foram aplicados questionários aos alunos da disciplina PSP5. Em dezembro de 2016 foram aplicados dois questionários, sendo um direcionado para as equipes que executaram projetos seguindo os princípios tradicionais e um direcionado para as equipes que utilizaram princípios ágeis. A disciplina era composta por 51 alunos e foram obtidas 22 respostas direcionadas aos times tradicionais e, para os times ágeis, 25 respostas. Posteriormente, em julho de 2017, os questionários foram aplicados novamente na mesma disciplina, obtendo-se 21 respostas, e a variável Desempenho pôde ser mensurada mediante uma análise multivariada.

Para realizar a análise multivariada, optou-se pelas equações estruturais via variância, visto seu caráter adequado para estudos que possuem um tamanho amostral pequeno (Hair, *et al*., 2016). É importante salientar que as equações estruturais com variância são uma técnica que mesclam econometría e psicometría em uma única análise e por isso os valores de R^2, são fracos (se R2≥ 0,13 e R2≤ 0,33), moderados (se R2≥0,33 e R2≤0,55) e considerados satisfatórios (se R2≥0,55) (Hair, *et al.* 2016)

Para analisar os dados, utilizou-se o software SmartPLS (*Smart Partial Least Square*), o qual utiliza equações estruturais para a análise multivariada. Por meio deste software, foi identificada a relação que cada variável tem com a variável Desempenho. As variáveis Desempenho e Custo Homem-hora são compostas por três indicadores. As variáveis Cliente, Risco e Qualidade são caracterizadas por quatro indicadores e, Tempo, é composto por dois indicadores.

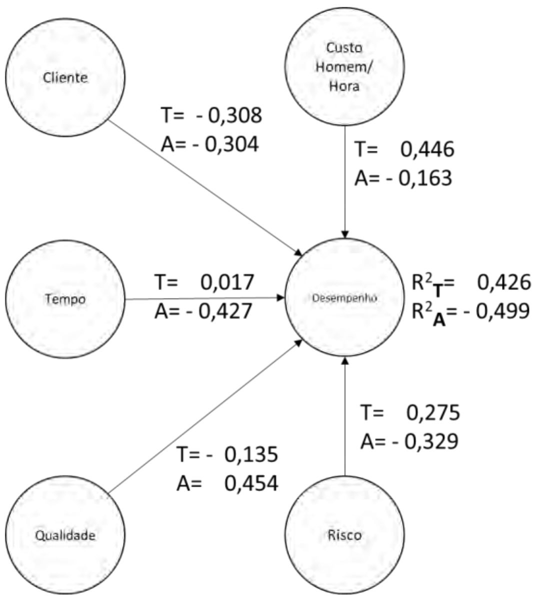
4 Resultados e Análises

4.1 Resultados

De acordo com Chin (1998), para analisar os dados por equações estruturais é necessário inicialmente criar o modelo estrutural a partir das relações presentes na literatura. Vieira (2017) destaca a importância de todo instrumento de pesquisa ser confiável e válido. Sendo assim, após obter o modelo de equações estruturais e atribuir os seus dados é preciso realizar testes estatísticos para verificar a confiabilidade e a validade do modelo e do instrumento de pesquisa. Foram realizados todos os testes nos modelos de pesquisa para projetos tradicional e ágil e os resultados foram satisfatórios.

Após confirmado que o modelo e instrumento são confiáveis e válidos, inicia-se a análise do modelo estrutural. O primeiro passo é a validação dos coeficientes de determinação de Pearson (R^2), que busca medir o poder de predição das variáveis independentes sobre a dependente (Ramirez, Mariano & Salazar, 2014). Os valores de R^2 aparecem na figura 1, ao lado direito do variável desempenho. Eles podem variar de 0 a 1 e quanto mais próximo 1, melhor a explicação. De acordo com Chin *et. al*. (1998), para que as variáveis independentes sejam explicadas satisfatoriamente pelo R^2, o seu valor deve ser superior ou igual a 0,1. No modelo voltado para os Times Tradicionais, as variáveis latentes Cliente, Custo Homem-Hora, Qualidade, Risco e Tempo predizem Desempenho em 42,6% de confiança, considerado aceitável. No modelo direcionado aos Times Ágeis, as variáveis latentes Cliente, Custo Homem-Hora, Qualidade, Risco e Tempo predizem Desempenho em 49,9% de confiança, sendo considerado aceitável.

Figura 1. Modelo de Equações Estruturais



Fonte: Elaborado pelo autor com base nos resultados do *SmartPLS*

Porém pode-se perceber que o uso de projetos pela abordagem ágil o desempenho tende a ser percebido e explicado de maneira mais forte que em projetos tradicionais.

O próximo passo é calcular o beta (β), que representa o grau em que uma variável pode influenciar a outra, apontando quais delas são mais importantes na tomada de decisão. Para ser considerado aceitável, o valor de β deve ser superior ou igual a 0,2 (Chin, 1998). Na figura 1 os valores de β obtidos nos dois modelos aparecem próximo as setas que ligam cada variável a variável dependente “desempenho”.

Pode-se observar na figura 1, que nos Times Tradicionais, a variável Custo Homem-Hora é a que apresenta maior influência em relação à variável Desempenho e a variável Risco explica o Desempenho em uma relevância significativa, uma vez que possui grau de 0,275. As variáveis Cliente, Qualidade e Tempo não demonstraram significância nesta relação, pois apresentam valores menores que 0,2.

Já com relação aos resultados de modelo aplicado aos Times Ágeis, apenas a variável Qualidade teve β maior que 0,2, o que significa que é a variável que mais influencia o Desempenho do projeto, porém pode-se perceber que as variáveis risco, tempo e cliente aparecem como inversamente proporcionais aos efeitos de desempenho. Isso significa que em um ambiente de alto risco, maior prazo (tempo) e maior controle do cliente não é o ideal para este tipo de abordagem em metodologias ativas. A variável Custo Homem/Hora teve o β menor que 0,2, podendo inferir que não apresenta influência significativa.

4.2 Análises

A variável que mais exerce influência significativa no Desempenho dos projetos executados seguindo abordagem Tradicional é o Custo Homem-Hora, e os dois indicadores que reforçam o maior Desempenho do projeto são a quantidade de horas que cada membro se dedica semanalmente ao projeto e a quantidade de vezes que os membros dos times se reuniram ao longo do projeto. Isso pode ser explicado pelo fato da abordagem Tradicional demandar muitos esforços por parte da equipe na realização dos projetos para que estes tenham bom desempenho. Segundo Mustaro e Rossi (2013), o planejamento é o grupo com o maior número de processos e visa definir e refinar as ações necessárias para atingir os objetivos do projeto, e consome um longo tempo no projeto.

Já em relação aos projetos executados pelos Times Ágeis, a variável que exerce maior influência no Desempenho é a Qualidade, e isso pode ser explicado pelo fato do método ágil ser muito orientado para haver validações constantes com os clientes, práticas que são definidas essenciais neste método. A variável Custo Homem-Hora pode não ter tanta influência no desempenho do projeto pelo fato de, segundo Hass (2009), a abordagem ágil permitir melhor equilíbrio entre o tempo de planejamento inicial e um gerenciamento de processo de mudança interativa, focando na adição de valor para o cliente.

Observou-se também que a influência inversamente proporcional do tempo em relação ao desempenho, em projetos ágeis foi um resultado inesperado, uma vez que a literatura indica que o prazo é um fator de sucesso do desempenho do projeto. Porém isso pode ser explicado, uma vez que em projetos com maior prazo são indicados uso da metodologia tradicional. Adicionalmente, se percebeu, que os projetos executados por princípios ágeis apresentaram melhor desempenho que os executados pela abordagem tradicional de gerenciamento de projetos. Deste modo aconselha-se o uso da abordagem ágil para conseguir um melhor desempenho nos projetos executados pelos discentes como produto da metodologia ativa na amostra pesquisada na Universidade de Brasília.

Embora existam estudos que façam comparação entre projetos ágeis e tradicionais (dos Santos, 2004; Eder, *et. al.*, 2015), não foram encontrados estudos para a área de aprendizagem, fazendo este estudo ainda mais interessante em suas contribuições. A perspectiva da aprendizagem, onde o desenvolvimento do discente é mais importante do que o resultado final do projeto em si, necessita de um estudo isolado, devido a essas necessidades específicas pautadas na educação.

Em um estudo em empresas Eder, *et. al.*, (2015), encontrou, por meio de uma revisão sistemática 6 fatores responsáveis por diferenciar a metodologia ágil da tradicional: a forma de elaboração do plano do projeto, forma como se descreve o escopo do projeto, O nível de detalhe e padronização com que cada atividade do projeto é definida, horizonte de planejamento das atividades da equipe de projeto, a estratégia utilizada para o controle do tempo do projeto e a estratégia utilizada para a garantia do atingimento do escopo do projeto.

Alguns destes fatores foram ratificados na diferenciação, como os tópicos relacionados ao planejamento e o escopo, que apresentaram nesta pesquisa caráter diferenciador.

5 Considerações finais, limitações e futuras linhas de pesquisa

Com as análises realizadas pode-se concluir que, no contexto estudado na disciplina PSP5, variáveis diferentes podem exercer maiores ou menores influências no desempenho do projeto de acordo com a abordagem de gerenciamento de projeto que for aplicada pela equipe de projeto. Como no caso dos times Tradicionais as variáveis influenciam 42,6% o Desempenho e no caso dos times Ágeis as variáveis influenciam 49,9% o Desempenho, seria fundamental pesquisar quais seriam as outras variáveis que influenciam o Desempenho de forma mais significativa em cada tipo de abordagem de gerenciamento de projetos. Assim, o problema desta pesquisa que era saber qual a melhor abordagem de projetos em metodologias ativas foi respondida como ágil., porém em ambientes com maior risco e maior prazo o sugerido é usar a abordagem tradicional. O fator controle do cliente aparece como indesejado para ambas as abordagens, acredita-se que está relacionado ao fato de se tratar da interação estudante-cliente, pois ao ter um cliente mais controlador, os discentes têm menor possibilidade de usar sua criatividade, alterando sua percepção da atividade.

Finalmente o objetivo da pesquisa que era realizar uma análise comparativa entre o desempenho dos projetos que foram executados de acordo com a abordagem tradicional de gerenciamento de projetos e os que foram executados seguindo a abordagem ágil de gerenciamento de projetos na disciplina PSP5 foi alcançado.

É importante ressaltar que estes resultados podem apresentar mudanças se aplicados a projetos executados fora do ambiente universitário e de aprendizagem ativa. Para futuras linhas de pesquisa aconselha-se aplicar este instrumento a mais grupos e a uma amostra maior ou em uma perspectiva longitudinal.

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Active Methodology as a voice for Engineering students: An Inclusion and Diversity experience via online platform.

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Abstract

The Production Engineering Course of the University of Brasília (EPR / UnB) has since 2009 adopted the PBL (Project Based Learning - PBL) as an active teaching methodology. Although every semester will be a new experience as the interactions between students and stakeholders from different spheres (public, private, service organizations, large, medium and small industries, among others), served by the projects. However, part of this experience, which occurs in the presentations of the projects to the stakeholders, were lost, since it was not possible to store it for future moments. Thus, the course of Production Engineering of the University of Brasília, started in 2016 an extension through events as a PBL product. The results were satisfactory, involving 458 students and 7910 participants. As a legacy, it was possible to create a platform for the presentation of active learning methodologies for the exchange of experiences (www.eventndo.com). Thus, the work presentations that were once a landmark, begin to build a history through an event, assisted and accessed as a course memory and student digital portfolio. However, there was a greater gain at the end of the project: inclusion. In this way, the platform allowed to measure the degree of inclusion that could be observed through the participation of men, women, afro-descendants, foreigners, people of high and low income, besides fomenting the active methodology and managing the knowledge. But this inclusion goes beyond social labels, it contemplates the possibility of giving voice to the students in the classroom, giving the opportunity to all the students to report their experience. Thus, the objective of this work is to present the online platform created by EPR-UnB, which has become a symbol of inclusion.

Keywords: Active Methodologies, Inclusion, Diversity, New Technologies

Metodologia Ativa como voz para os estudantes de Engenharia: Uma experiência de Inclusão e Diversidade via plataforma on-line.

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Resumo

O Curso de Engenharia de Produção da Universidade de Brasília (EPR/UnB) adotou desde 2009 o PBL (*Project Based Learning - PBL*) como metodologia ativa de ensino. Apesar de cada semestre ser uma experiência nova quanto as interações entre alunos e *stakeholders* de diferentes esferas (organizações públicas, privadas, de serviço, indústrias de grande, médio e pequeno porte, entre outras), atendido pelos projetos. Porém parte desta experiência, que ocorrem nas apresentações dos projetos aos *stakeholders*, se perdiam, já que não era possível estocá-la para futuros momentos. Deste modo, o curso de Engenharia da Produção da Universidade de Brasília, iniciou em 2016 uma extensão por meio de eventos como produto PBL. Os resultados foram satisfatórios, envolvendo 458 alunos e 7910 participantes. Como legado, se obteve a criação de uma plataforma de apresentação de metodologias ativas de aprendizagem para intercâmbio de experiências (www.eventndo.com). Assim, as apresentações de trabalho que antes eram um marco pontual, passam a construir um histórico por meio de um evento, assistido e acessado como memória do curso e portfólio digital do aluno. Porém, houve um ganho maior ao final do projeto: a inclusão. Desta maneira, a plataforma permitiu mensurar o grau de inclusão que pôde ser observado por meio da participação de homens, mulheres, afrodescendentes, estrangeiros, pessoas de alta e baixa renda, além de fomentar a metodologia ativa e gerir o conhecimento. Mas esta inclusão vai além de rótulos sociais, ela contempla a possibilidade de dar voz aos alunos em sala de aula, dando a oportunidade a todos os discentes de relatarem a sua experiência. Assim, o objetivo deste trabalho é apresentar a plataforma *on-line* criada pela EPR-UnB, que se tornou símbolo de inclusão.

Palavras-Chave: Metodologias Ativas, Inclusão, Diversidade, Novas tecnologias

1 Introdução

Encontrar uma maneira de compreender o contexto da educação brasileira é de certo modo uma tentativa de compreender o Brasil: um desafio. Barbosa & Moura (2013), definem o cenário de ensino brasileiro como uma *ansiedade indefinida*, marcada por um perfil cambiante do aluno, das instituições de ensino e do contexto do o país. Assegurar uma maneira de dar voz a todos os atores envolvidos na formação parece ser uma tarefa impossível, principalmente na perspectiva do discente representante de minorias. Araújo (2011), explica que no Congresso Mundial sobre o Ensino Superior, organizado pela Organização Educacional Científica e Cultural das Nações Unidas – UNESCO em julho de 2009 em Paris, onde participou cerca de 150 países, um dos temas principais dos debates e do documento final do evento foi a importância de priorizar políticas que ampliem o acesso ao ensino superior, ao mesmo tempo que almejem a qualidade e a equidade na educação.

Adicionalmente o documento explica que este objetiva deveria ser atingido por meio das tecnologias, via sistemas educativos baseados em *"open and distance learning (ODL)"* e utilização de Tecnologias de Informação e Comunicação (TICs) (Araújo, 2011).

A tecnologia sempre fez um papel paradoxo na educação, em alguns momentos permitiu diminuir a distância entre as necessidades da aprendizagem e em outros foi utilizada indevidamente em conteúdos ainda não adaptados para difusão a distância por meio da EaD(Educação à Distância). Assim, assegurar a voz ativa do aluno, adequação às novas tecnologias e a aprendizagem se tornou uma preocupação das instituições de ensino. Uma resposta que vem gerando bons resultados está relacionada ao uso de metodologias ativas (Blackburn,2017; Gunter & Alpat; 2017).

O curso de Engenharia da Produção da Universidade de Brasília (EPR-UnB), desde 2011, vem adotando o uso da metodologia ativa via *Project Based Learning* – PBL e em 2016 passou adotar o uso da uma plataforma on-line a fim de divulgar os principais resultados obtidos em seus projetos realizados pelos alunos. Porém os resultados foram maiores do que o esperado, pois a plataforma que era inicialmente para difusão das práticas de PBL, passaram a ser uma plataforma de inclusão, permitindo voz a todo aquele aluno interessado em participar, que antes, principalmente, por uma questão operacional (tempo de sala de aula) não era possível.

Assim o objetivo deste trabalho é apresentar a plataforma *online* criada pela EPR-UnB, que se tornou símbolo de inclusão.

2 Fundamentação teórica

2.1 Inclusão na Educação

Tentar encontrar uma face única para inclusão é de certa forma estar excluindo. O processo de inclusão perpetua por diferentes fatores como renda, gênero, raça, distúrbios psicomotores, entre outras (Rodrigues, 2006; Matiskei, 2004; Vianna, 2012).

Porém todas possuem um fator em comum que é o silêncio. O aluno que não se sente incluído não participa, não interage, proporcionando a aula uma dinâmica pobre. Aujla-Bhullar (2016), explica que existe uma necessidade do avanço sobre a noção de diversidade, visto o desafio duplo de ser incluído na educação superior e representar sua identidade plural social, cultural e econômica no processo de aprendizagem.

Neste contexto o docente possui um papel fundamental de gerir uma sala de aula onde toda a diversidade esteja representada. Adicionalmente aos problemas específicos a cada realidade, todos os professores se deparam com uma perspectiva operacional muito simples no momento de integrar está diversidade por meio da participação: o tempo.

As aulas normalmente ocorrem em uma carga horária específica para se desenvolver o conteúdo e organizar a fala de cada indivíduo presente. Muito antes de se pensar na diversidade, o fator tempo já era em si um desafio, endo no contexto atual uma tarefa ainda mais árdua.

Vanslambrouck, *et al.* (2017), explica que no contexto da diversidade, a tecnologia via aprendizagem *on-line* possui um papel fundamental ao individualizar a educação. A possibilidade de desenhar um perfil para cada aluno e dotar este de voz é uma solução enriquecedora para o processo educativo. Embora a tecnologia possua este papel integrador na educação, seu próprio uso traz consigo um tipo de exclusão, associado ao seu próprio acesso. Porém, diante das discussões e tentativas reais de uma solução mais sustentável, de momento parece ser que é por meio da tecnologia que a inclusão possui seu caráter mais operativo, concedendo voz ao indivíduo.

Assim, o uso da tecnologia pode ser um instrumento de contribuição aos modelos sociais-construtivistas, atendendo as demandas de desenvolvimento econômico e social dos indivíduos, por meio de um pensamento crítico e da colaboração.

2.2. As metodologias ativas e a inclusão

Araújo (2016), descreve a metodologia ativa como aquela centrada no aluno, protagonizando sua aprendizagem e secundarizando o ensino. Embora os objetivos das metodologias ativas estejam associados a melhoria da aprendizagem, traz consigo, um caráter inclusivo. Ao longo do tempo as metodologias ativas foram adaptando-se as necessidades da aprendizagem, passando pela adoção das tecnologias, novos perfis de aprendizagem e mais recentemente o papel de inclusão da diversidade em sala de aula.

O curso de Engenharia de Produção da universidade de Brasília (EPR-UnB), adota o uso de PBL (*Project Based Learning*), desde 2011. Desde então vêm avançando no contexto das metodologias ativas e se adaptando para cumprir com as necessidades cambiantes da educação no Brasil e no mundo. Em 2016, o EPR-UnB, decidiu adotar o Evento On-line como legado do PBL, utilizado no curso.

3 Métodos

Esta pesquisa é do tipo exploratória via estudo de caso com abordagem qualitativa. O local do estudo foi a Universidade de Brasília-DF-Brasil. O objeto de estudo foi a plataforma de difusão de resultados PBL, desenvolvida no curso de Engenharia de Produção.

Foram analisados os resultados e efeitos durante dois semestres do uso da plataforma na inclusão do aluno. Para isso foi realizado um estudo de caso explicando o desenvolvimento da plataforma e seus resultados, assim como avances futuros.

O objetivo do Evento como produto do PBL, era difundir os resultados dos projetos dos discentes, pois seu legado transpassava a experiência dos alunos e os projetos entregues com as soluções aos problemas reais. Um legado eu ficava prejudicado eram aqueles de ordem temporal, apenas disponível em um momento “T” no ciclo de vida da disciplina. Deste modo a EPR-UnB criou uma plataforma on-line (www.eventndo.com) numas uma tentativa de estender esta experiência e gerir o conhecimento que atualmente está caracterizado como perecível, pois não é possível estocá-lo para futuros momentos (Mariano, et al., 2017).

O intuito desta plataforma não era apenas ampliar o alcance dos resultados e sim promover o compartilhamento de ideias e o contato entre universidades com diferentes metodologias ativas.

A plataforma começou em 2016.1 e em 2017.1 os resultados eram positivos. 458 alunos envolvidos no processo e 7910 participantes oriundos de diferentes regiões do Brasil e do mundo participaram do Chat on-line, assim como das discussões sobre os projetos apresentados. Países como Bolívia, Chile, Colômbia, Reino Unido, Espanha, Itália, Portugal e Angola, participaram do evento on-line.

Neste contexto, efeitos indiretos também aconteceram, como uma maior participação dos alunos, integração do corpo docente e maior integração da tecnologia nas aulas. Porém o fator que mais chamou a atenção como efeito indireto inicial foi a inclusão por meio da plataforma. Os professores perceberam que muitos dos alunos que normalmente não se manifestavam em sala de aula passaram a gravar seus vídeos, dar suas opiniões e interagir com alunos de outras universidades no Brasil e mundo.

4 Resultados

4.1 Breve cenário

Em 2001, na III Conferência Mundial contra o Racismo, Discriminação Social, Racismo, Xenofobia e Intolerância Correlata tonou-se um marco para o Brasil tratar de temas relacionados a inclusão e ações afirmativas. Mas foi em 2003 que a Universidade de Brasília instituiu formalmente a inclusão por meio das quotas, inicialmente para negros e indígenas (Cardoso, 2008). Embora muitas ações são anterior a ação formal institucional, este marco propiciou uma discussão sobre o tema, muitas vezes esquecido nas pautas acadêmicas.

Porém o processo de inclusão se ampliou e hoje o respeito pela diversidade é uma pauta importante dentro da Universidade de Brasília- UnB. Entretanto, o reconhecimento não é suficiente, é necessário a existência de um espaço para discussão dos múltiplos grupos em sala de aula. Ou seja, existe um desafio ainda maior em conceder voz a todos os alunos e ao professor em um ambiente de desenvolvimento pedagógico construtivo.

A Universidade de Brasília em 2016 possuía 37.982 alunos matriculados em cursos de graduação. Dentre todos os cursos da faculdade de tecnologia (Engenharia Civil e Ambiental, Engenharia Elétrica, Engenharia Florestal, Engenharia Mecânica e Engenharia de Produção), apenas a Engenharia de Produção funciona via PBL. Apesar de estar consolidado, sendo até a atualidade o segundo melhor curso de Engenharia de Produção do Brasil (Mariano, *et al.*, 2017), os professores continuam avançando em pesquisas com a finalidade de assegurar a perpetuidade do ensino de qualidade oferecido.

Um desafio do Curso de Engenharia de Produção, é conciliar um ensino de qualidade com temas atuais como tecnologia e diversidade, aportando a sociedade um profissional completo. Em uma primeira aproximação o EPR-UnB adotou o PBL, uma metodologia ativa que favorece a colaboração entre professor e aluno que aprendem juntos. Mesmo não sendo a principal ação, os estudantes ganharam uma participação mais ativa, inclusive no desenho da metodologia ativa com *feedbacks* semestrais, favorecendo o crescimento e estabelecendo uma linha própria, uma identidade da Universidade de Brasília na metodologia ativa.

O PBL na Universidade de Brasília funciona da seguinte maneira: o professor recebe demanda de empresas locais a respeito de problemas reais. Estas empresas são convidadas a expor seus problemas aos alunos, que se organizam em grupos e durante um semestre, realizando reuniões com os responsáveis e posteriormente oferecendo uma solução via projetos (exemplo da disciplina de PSP5).

Porém, em 2016, a EPR-UnB percebeu que muitos dos trabalhos eram apenas disfrutados em sua totalidade aos presentes no momento da apresentação, e que muitos alunos não se envolviam ativamente no processo de construção como era esperado pelo professor.

Assim, tentar conciliar o aumento do uso das tecnologias, fomento de participação dos alunos e os desafios de inclusão da universidade contemporânea foi diagnosticado como o principal problema deste cenário.

4.2 Plataforma

Numa tentativa de responder ao cenário contextualizado anteriormente a EPR-UnB, desenhou uma plataforma para a difusão dos resultados PBL. A ideia era que as apresentações fossem gravadas em vídeos em um formato de pôster e difundidas por um site onde os alunos, clientes e sociedade pudessem assistir e ao final interagir com um *Chat online*. O desenho da plataforma pode ser observado na figura 1.

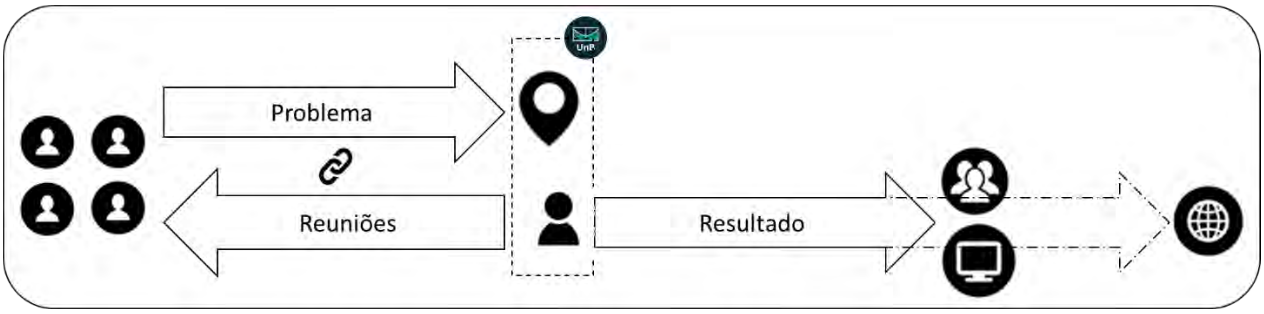

Figura 1. Modelo da plataforma

Fonte: Própria

Inicialmente os clientes levam problemas reais, que são contemplados pelos alunos sob tutela do professor. Em seguida os discentes passam a realizar reuniões consecutivas a fim de obter dados e construir o projeto para resolu4ao do problema. Após construído o modelo, os resultados são apresentados ao cliente. Porém, com a plataforma *on-line* (www.eventndo.com) este resultado se ampliou e pode criar um registro para acesso futuro por parte da empresas, alunos e sociedade, gerindo o conhecimento. O fato das apresentações serem oferecidas em inglês, espanhol e português facilitou a cooperação com outras universidades e países.

Até então este desenho foi aplicado e os resultados superaram as expectativas. Mas um efeito indireto ganhou uma grande repercussão: a inclusão do aluno. Por meio da plataforma *on-line* e do *Chat on-line*, o momento da apresentação ganhou o espaço necessário para difusão dos resultados. Assim qualquer aluno pode realizar sua intervenção via vídeo ou *Chat on-line*, desta forma amplia-se o tempo de sala de aula para aquele necessário a cada estudante para se expressar, permitindo construir seu discurso e participação da melhor maneira possível.

4.3 Resultados da Plataforma

Os resultados foram notórios. Os professores envolvidos no programa começaram a perceber a atuação ativa de alunos que antes se resguardavam em sala de aula. Os representantes das equipes e as linhas de argumento romperam rótulos de gênero, raça, classe social, opção sexual ou comportamento. As interações via chat foram ricas, promovendo uma discussão com diversidade e por meio de argumentos desafiadores para o Engenheiro de Produção.

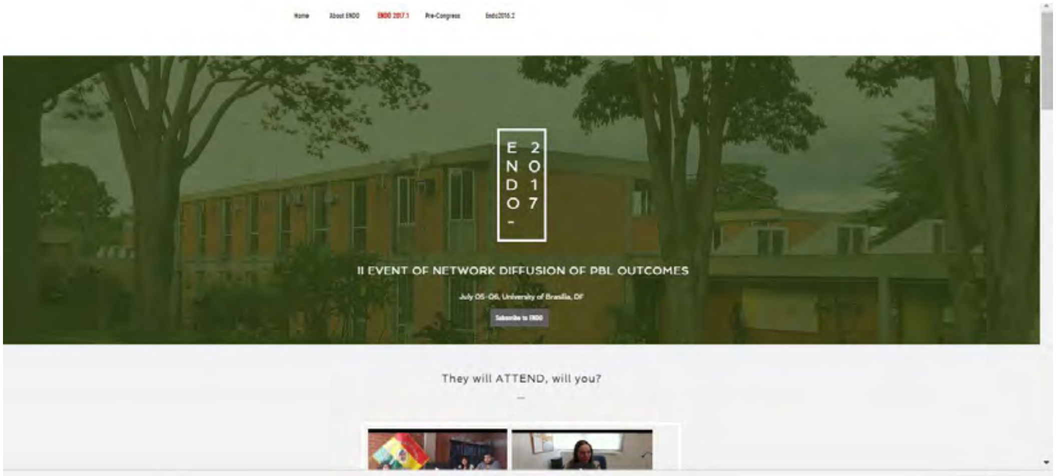

Figura 2. Plataforma
Fonte: Própria

A participação fomentou a colaboração de professores de várias instituições e áreas do conhecimento, que se manifestaram com vídeos comprometendo-se a participar do evento *on-line*, junto a sua instituição.

4.4 Avances

Para 2017.2 se configurou mais um avance na plataforma: o uso da linguagem dos sinais em umas das salas piloto do evento, com a finalidade de promover maior integração junto a diversidade de assistentes. Embora os vídeos já possuíssem a possibilidade de serem assistidos com legendas, a linguagem dos sinais é um símbolo de lembrança e respeito, sendo por isso um avance muito importante.

5 Considerações finais, limitações e futuras linhas de pesquisa

O objetivo deste trabalho foi apresentar a plataforma *online* criada pela EPR-UnB, que se tornou símbolo de inclusão. Este objetivo foi alcançado demonstrando que a Plataforma de Difusão de Eventos PBL é um marco na inclusão do aluno, permitindo-o expressar-se no momento que acreditasse ser pertinente, assim como continuar se expressando e sendo exemplo por meio da memória de eventos anteriores. Acredita-se que com os avances da plataforma a inclusão seja ainda mais efetiva, promovendo a diversidade em ambiente de aprendizagem. Isso permita afirmar que os caminhos escolhidos pela EPR-UnB têm levado suas práticas a uma aderência real dos problemas locais, colocando a metodologia ativa como agente de integraç4ao da diversidade.

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Integrating active methodologies with scientific research: An experiment applied to a Production Engineering Course.

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Abstract

Universities have as their role the education of the individual, which in the context of higher education corresponds to three axes: teaching, extension, and research. Although there are active methodologies such as the Inquiry-Based Learning (IBL), which has in some of its stages the use of scientific research, actions with a direct focus on extension or research are still timid. The objective of this work was to propose an initiative to foster academic research as a means of active learning. To achieve this goal, a Research Support, and Development Nucleus (NADESP) was created (https://nadesp.wordpress.com) that integrates the contents learned in the disciplines through scientific research. Unlike Inquiry-Based Learning (IBL), this method does not pose problems for students, it provides scientific methods to solve the problems they usually have in regular subjects. If a student needs a tool to measure a problem in the logistics or quality management class, NADESP is willing to accompany him in this discovery, training and, in the end, in the preparation of scientific papers. Thus, knowing the latest approaches, real cases of application, tools that best fit your problem in a specific discipline, measurement scales, among others, are goals pursued by this action that unites research and teaching. That is, it is to put at the service of students the rigor of science, fostering research and forming a more analytical and complete professional. The results achieved helped to improve the research substantially, and only in the semester 2017.1 did the students reach 102 publications and 4 national and 2 international research awards. Thus, the NADESP initiative in the Production Engineering Course of the University of Brasília has not only improved the number of articles, it has also increased the integration among teachers who started to publish together and give more depth to the students in the knowledge of the disciplines.

Keywords: Active Methodologies, Production Engineering, Applied Scientific Research, University of Brasília

Integração das metodologias ativas a pesquisa científica: Uma experiência aplicada a um Curso de Engenharia da Produção.

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Resumo

As Universidades têm como seu papel a educação do indivíduo, que no contexto do magistério superior corresponde a três eixos: ensino, extensão e pesquisa. Embora existam metodologias ativas como o Inquiry-Based Learning (IBL), que possui em alguma de suas etapas o uso da pesquisa científica, ainda são tímidas as ações com foco direto em extensão ou pesquisa. O objetivo deste trabalho foi propor uma iniciativa para fomentar a pesquisa acadêmica como meio de aprendizagem ativa. Para alcançar este objetivo foi criado um Núcleo de Apoio e Desenvolvimento à Pesquisa- NADESP (https://nadesp.wordpress.com) que integra os conteúdos aprendidos nas disciplinas via pesquisa científica. A diferença do Inquiry-Based Learning (IBL), este método não propõe problemas aos alunos, ele aporta métodos científicos para resolver os problemas que possuem usualmente nas disciplinas regulares. Se um discente precisa de uma ferramenta para mensurar um problema da aula de logística ou gestão da qualidade, o NADESP está disposto a acompanha-lo nesta descoberta, formação e ao final, na confecção de trabalhos científicos. Assim, conhecer as abordagens mais recentes, casos reais de aplicação, ferramentas que melhor se adequam ao seu problema em uma disciplina específica, escalas de medida, entre outros, são metas perseguidas por esta ação que une pesquisa e ensino. Ou seja, é colocar a serviço dos alunos o rigor da ciência, fomentando a pesquisa e formando um profissional mais analítico e completo. Os resultados alcançados ajudaram a melhorar substancialmente a pesquisa, sendo que apenas no semestre 2017.1 os alunos alcançaram 102 publicações e 4 prêmios nacionais e 2 internacionais de pesquisa. Assim pode-se perceber que a iniciativa NADESP no Curso de Engenharia de Produção da Universidade de Brasília, não tem apenas melhorado a quantidade de artigos, ela também aumentou a integração entre professores que passaram a publicar juntos e dar mais profundidade aos discentes no conhecimento das disciplinas.

Palavras-Chave: Metodologias Ativas, Engenharia de Produção, Pesquisa cientifica aplicada, Universidade de Brasília

1 Introdução

Avaliar a efetividade do ensino superior não apenas no Brasil, como no mundo tem sido uma tendência em pesquisas científicas na área de educação, políticas públicas, ou mesmo em administração universitária (Calvo-Mora, Leal & Roldan, 2005; Calvo-Mora & Garcia-Legaz 2005; Ramírez, Peña & Alfaro, 2012). E as pesquisas concordam que as publicações de alto-impacto são uma medida objetiva de ensino superior de qualidade.

Em março de 2014, foi divulgado no Brasil, pela *ONG Battelle Memorial Institute*, um ranking no qual posiciona os países que mais investem em tecnologia (pesquisa e desenvolvimento), a partir do valor de parcela do PIB (Produto Interno Bruto). Conforme dados da pesquisa, o Brasil encontra-se em 26º no ranking com um investimento de aproximadamente 1,3% do PIB destinado à pesquisa e desenvolvimento (P&D), e desde então estes números pioraram.

Sabe-se que todo processo relacionado à tecnologia é uma ação que envolve governo, como agente que proporciona incentivos, agências de fomento, a iniciativa privada, que normalmente é quem se utiliza das inovações, integrando a pesquisa básica para oferecer a pesquisa aplicada e as Universidades, IES, e centros de pesquisa, responsáveis pela massa crítica da ciência. Embora em alguns países, os papeis que assumam cada elemento possa mudar, no Brasil, é na interação entre o docente, seus pares e alunos que reside o diferencial competitivo da pesquisa e consequentemente da inovação no Brasil.

Porém, poucos são os cursos de graduação que oferecem iniciativas, excetuando os programas de iniciação científica, que ocorrem em uma esfera institucional. Na prerrogativa dos cursos, ainda existe uma dificuldade de integrar a pesquisa em etapas tão precoce do estudante, levando-o a ter contato com a investigação apenas em etapas posteriores.

Ao compreender a importância dessa relação, é possível aproximar a pesquisa do papel do educador, inserindo-a no ensino superior como elemento fundante e norteador da prática educativa. Nesse contexto, ela se apresenta não só como metodologia, mas também como oportunidade para criar um ambiente interdisciplinar, analisando o mesmo problema sob diversos olhares, a partir do trabalho cooperativo (Araújo & Salgues, 2009).

Foi neste contexto que, em 2012, nasceu o Núcleo de Apoio e Desenvolvimento à Pesquisa (NADESP), com a finalidade de promover e fomentar a pesquisa a nível da graduação. Foi uma tentativa de resgatar uma pesquisa mais aplicada para o aluno e garantir uma melhoria por meio da investigação em todo processo de formação. A pesquisa já vem sendo adotada como metodologia ativa (*Inquiry-Based Learning*), há algum tempo (Mariano. *et al.*, 2017). Entretanto os alunos são conduzidos a resolver um problema específico por meio de leitura e busca bibliográfica. No NADESP o aluno aprende métodos de pesquisa para integrar e testar a teoria, assim como dotar de rigor científico as solicitações das outras disciplinas em sala de aula. A literatura é clara, quando explica a importância da alfabetização científica e seus efeitos na formação do estudante (Sasseron & de Carvalho, 2016).

Assim, este estudo busca responder: qual o impacto do ensino por meio da metodologia ativa por meio da pesquisa científica?

Essa pesquisa é importante para compreender como a pesquisa científica aplicada pode contribuir na formação do aluno, favorecendo seu desenvolvimento como profissional.

Deste modo, o objetivo deste artigo foi propor uma iniciativa para fomentar a pesquisa acadêmica como meio de aprendizagem ativa.

Para alcança-lo vai ser realizado um estudo de caso apresentando as iniciativas do NADESP como iniciativa de metodologia ativa para os alunos de Engenharia de Produção da Universidade de Brasília-UnB (EPR-UnB).

2 Fundamentação teórica

2.1 Importância da Pesquisa Científica nas Universidades

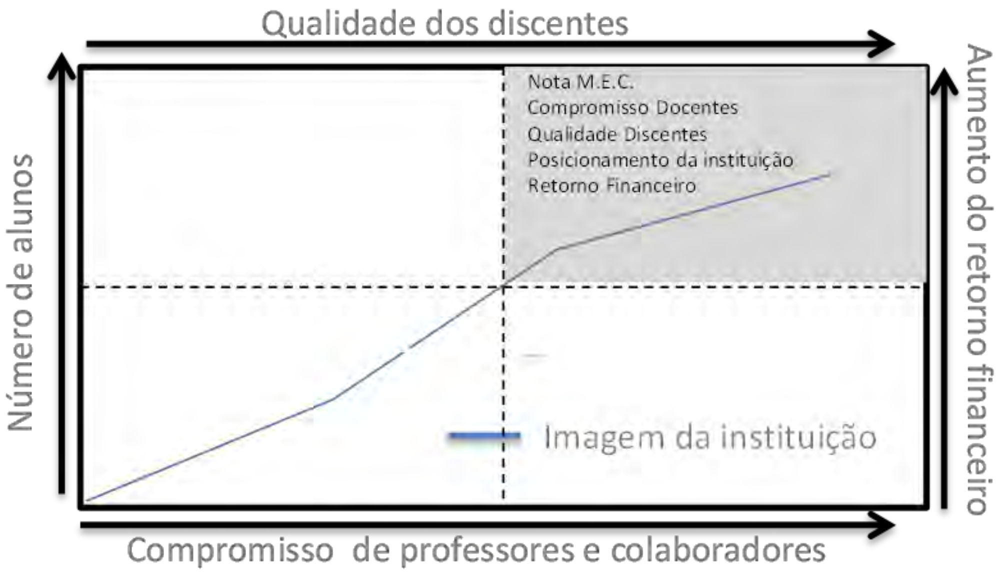
Atualmente, as melhores Instituições de Ensino Superior possuem como foco a produção de conhecimento, pautando seus processos na pesquisa e na investigação científica. Apesar de conhecimento e pesquisa se apresentam de forma dissociada no campo teórico, juntas representam uma das características mais importantes do conceito de educação: a possibilidade de aprimoramento constante (Feldmann, 2009).

Neste contexto, a inserção precoce do aluno de graduação em projetos de pesquisa se torna um instrumento valioso para aprimorar as qualidades desejadas nesse futuro egresso, bem como iniciar e incentivar a formação daqueles estudantes vocacionados para a área.

Apesar da maior parte dos alunos do ensino superior não conseguirem definir exatamente os procedimentos da pesquisa acadêmica, eles são capazes de avaliar seus impactos positivos na sociedade, bem como em sua formação acadêmica (Campos et al. 2009) Adicionalmente, Guimarães (2004), explica que promover a Ciência e educação de qualidade estão ligadas diretamente ao desenvolvimento econômico, industrial e tecnológico de uma nação. Assim, sendo a pesquisa um fator tão importante, se faz necessário incluir ela de maneira efetiva em etapas mais iniciais na vida do estudante. Embora esteja claro os benefícios da pesquisa, instituições públicas e particulares têm dificuldade de observar o benefício de um programa centrado na pesquisa.

Na figura 1, pode-se perceber os efeitos do uso da pesquisa em uma instituição de ensino:

Figura 1. Impactos da Pesquisa



Fonte: Própria

Toda vez que uma instituição tem como centro de sua política, a pesquisa, sua imagem institucional melhora, sendo reconhecida como referência em suas áreas de pesquisa, a melhoria da imagem impacta no aumento de alunos interessados. Com maior quantidade de alunos participando, o filtro de entrada fica mais exigente, fazendo com que a qualidade do aluno melhore também.

A pesquisa move fundos de fomento e com isso uma instituição com maior competência em pesquisa tende a ter mais fundos, melhorando a estrutura e métodos. Assim, em um contexto de pesquisa, com bons alunos, recurso financeiro e boa imagem institucional, a possibilidade de criar fidelidade e compromisso junto aos colaboradores e outros alunos é maior. Com estes ganhos a possibilidade de a Instituição gozar de melhor prestigio e nota junto ao Ministério da Educação (MEC), é maior.

2.2 Alfabetização científica

Embora seja um termo pouco ouvido nas áreas das Engenharias, a Alfabetização científica é alvo de muitas pesquisas (Bybee & DeBoer, 1994; Hurd, 1998; Gil-Pérez & Vilches-Peña, 2001; Norris e Phillips, 2003 e Membiela, 2007). O termo se refere a aplicação do conhecimento científico na resolução de problemas de seu cotidiano e por meio dele continuar aprendendo (Sasseron & de Carvalho, 2016).

Espera -se que os currículos contemplem a alfabetização científica nas universidades. Uma das iniciativas mais conhecidas é o Projeto 2001, da AAAS (1993), que promove esta alfabetização para ciências, matemática e tecnologia (Membiela, 2007).

Um discente que aprende métodos científicos durante a graduação, acaba por possuir um ferramental maior no momento de lidar com o mundo laboral, principalmente em um contexto em que se estão gerando muitos dados e se necessitando de um profissional com capacidade analítica.

Proporcionar a possibilidade do discente de continuar aprendendo por meio do rigor científico de aquisição e criação de conhecimento é garantir um profissional mais capacitado.

3 Métodos

Este estudo é exploratório, por meio de abordagem qualitativa e estudo de caso. O local de estudo é a Universidade de Brasília, Departamento de Engenharia de Produção-UnB. O objeto deste estudo foram as ações do Núcleo de Apoio e Desenvolvimento à Pesquisa-NADESP realizados no ano de 2017(Compreendido por março de 2017 a outubro de 2017). Essas ações ocorreram no Curso de Engenharia de Produção-UnB.

Foram levados em consideração para medidas de performance das ações, a quantidade de artigos publicados no ano de 2017 e a quantidade de artigos submetidos.

O desenho deste trabalho segue uma perspectiva de apresentar o NADESP como meio de inserir a pesquisa no cotidiano do aluno de graduação. O processo de implementação do NADESP, foi feito em etapas: a. Divulgação da proposta e formação inicial: nesta etapa se faz uma divulgação massiva da proposta de pesquisar na instituição e vantagens para a formação do aluno, as vagas para a formação inicial são abertas a todos os interessados, não sendo realizada entrevista ou mesmo seleção para fazer parte do grupo; b. seleção: ao final da formação 1, se faz um pedido de um artigo científico. Entre o processo de formação (frequência) e entrega do artigo 1, acontece a primeira seleção. Assim a medida que avançam as formações, se avançam os processos seletivos. c. Liderança: depois de concluir toda a formação (80 horas de classe e 5 aprovações de trabalhos) o aluno é convidado a assumir um posto de chefe de grupo, onde coordena uma equipe e realiza seu próprio processo seletivo; d. aprendizagem e formação: uma vez selecionado o grupo, os líderes começam a realizar uma formação de pesquisa acompanhada pelo professor tutor, assim por meio de estudar o conteúdo que aplicou em 3 semestres desde a perspectiva de tutor, lhe assegura uma nova forma de aprender.

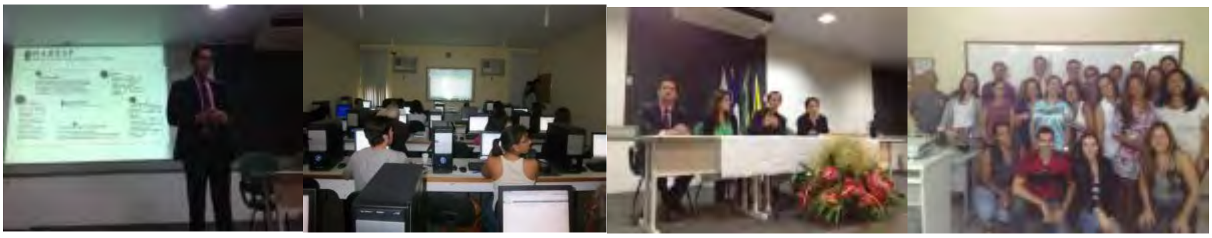
As formações começam com i. Introdução à pesquisa: cenário e fundamentos, ii. Elementos técnicos da pesquisa, iii. Revisão sistemática por meio da teoria do enfoque meta-analítico consolidado, iv. Pesquisa qualitativa, v. pesquisa quantitativa, vi. Técnicas avançadas de pesquisa, tratamento de dados e análise e vii. Avaliação da pesquisa científica.

4 Resultados e Análises

4.1. Núcleo de Apoio e Desenvolvimento à Pesquisa

Apesar de sua criação em 2012, o NADESP chegou na Universidade de Brasília em 2016. Muitas foram as ações realizadas nos anos anteriores, buscando integrar o rigor científico a pesquisa. O processo do NADESP costuma ser o mesmo. Inicialmente abre uma chamada para participação dos alunos. O que parece ser um processo seletivo na verdade são umas boas vindas onde se apresenta os objetivos do núcleo. Posteriormente se apresenta o cronograma de formação dos alunos. A formação em pesquisa acontece em 50 horas distribuídas em horários alternativos aos horários das aulas (Figura 2).

Figura 2. Montagem de fotos das formações



Fonte: Própria

Estas formações são realizadas presencialmente e associadas a um software, para operacionalizar uma proposta de pesquisa aplicada. São apresentadas aplicações reais destas pesquisas. Os professores em sua maioria vêm de Universidades do exterior, proporcionando aos estudantes uma visão diferenciada. Com pouco tempo de funcionamento do NADESP já pode perceber as mudanças na instituição e nos alunos, que passam a usar o ferramental nas disciplinas, melhorando seu desempenho, além das publicações conquistadas. Na figura 3 aparece alguns momentos de visitas de professores do exterior, assim como os alunos participando dos congressos e recebendo premiação pelos trabalhos apresentados.

Figura 3. Montagem de fotos dos momentos em congressos

Fonte: Própria

A postura do aluno ao voltar de um congresso muda. Desde sua relação com os professores, como sua participação em sala e interesse em continuar trabalhando com pesquisa.

Com a chegada do NADESP na EPR-UnB, foram realizados os mesmos passos que em outras instituições. Inicialmente eram 40 alunos interessados que receberam a primeira formação de 8 horas. Com o conhecimento sobre os princípios da pesquisa, se estabeleceu uma segunda data para continuidade da formação e um cronograma com principais congressos para envios.

O próprio processo de formação, como o cronograma duro de congressos foram em si filtros. Ao final do primeiro semestre do NADESP, se contava apenas com 9 alunos. Uma vez terminado todo processo de formação e atividades procedeu-se aos envios para 2017. Inicialmente foram escolhidos congressos por sua dinâmica de resultados, normalmente em três meses os alunos têm um retorno. Embora envio para revistas também sejam realizados, nas fases iniciais se aconselha a trabalhar com congressos, para dar segurança e melhorar a autoestima do pesquisador iniciante.

Porém, o grande diferencial do NADESP é a etapa 2 da formação, que consiste em atribuir grupos aos alunos formados para que repassem o que aprenderam, transformando-os em professores nestes grupos. O professor responsável pelo NADESP faz o seguimento das aulas para dar um *feedback* aos alunos.

Em 2017.1 os resultados já foram sendo obtidos via NADESP. Excedem as expectativas dos alunos, levando-os a realizar além da pesquisa, visitas técnicas, contatos com outros alunos de outras Universidades (Figura 4)

Figura 3. Montagem de fotos dos momentos em congressos 2017

Fonte: Própria

A volta dos alunos a sua Universidade depois de apresentar um artigo é sem dúvida a melhor recompensa. Pois são como agentes multiplicadores do processo, ocasionando em um aumento de interesse de todos os alunos.

Este efeito também se estende para a continuação das atividades de pesquisa. Os resultados de 2017 superaram todas as expectativas. Em 9 meses de trabalho no ano, os alunos conseguiram 102 publicações em congressos nacionais e internacionais, 4 prêmios nacionais e 2 internacionais, levando o NADESP a marca de 10 prêmios desde sua criação. Ainda na finalização deste trabalho se aguarda o resultado de outros 6 trabalhos (Figura 4).

Figura 4. Montagem de fotos com premiações e aprovações

Fonte: Própria

O efeito das aprovações fez com que os alunos do NADESP fossem procurados para fazer artigo com outros colegas e professores, ampliando o alcance para mais artigos do que os registrados neste documento. No último curso realizado para alunos de mestrado e doutorado, os alunos atuaram como monitores, sendo convidados a comparecer nos programas e acompanhar os colegas em níveis maiores de formação.

Os acadêmicos envolvidos no NADESP forma convidados a participar de programas de mestrado no país e fora do país. Como profissionais, o rigor científico os transformou em um profissional mais completo, e muitos dele resolveram continuar ampliando seu conhecimento por meio do mestrado.

Assim pode-se concluir que as ações do NADESP foram de grande relevância e por conta de seus resultados, ao final de agosto, o núcleo foi convidado a compor o Centro Interdisciplinar de Estudos em Transportes-Ceftru.

5 Considerações finais, limitações e futuras linhas de pesquisa

O objetivo deste artigo foi propor uma iniciativa para fomentar a pesquisa acadêmica como meio de aprendizagem ativa. Este objetivo foi alcançado ao explicar a iniciativa NADESP que possui um total de 7 prêmios de pesquisa, sendo três apenas em 2017.

A implementação do Núcleo é uma tarefa complexa, pois os alunos participantes não recebem bolsa ou qualquer ajuda de custo, apenas unidos pela vontade de aprender. O Núcleo proporciona ao aluno uma formação sólida em ferramentas de pesquisa e conceitos transversais que podem ser aplicados em diversas áreas. Esta formação leva ao aluno a uma melhoria no processo de compreender a universidade.

Assim o problema desta pesquisa foi respondido ao constatar que o impacto da pesquisa no desempenho do aluno é real, concluindo que os efeitos do NADESP no curso foram relevantes.

O tempo dedicado ao projeto por parte do professor costuma ser mais de 20 horas semanais. Mas com o passar de dois anos e o processo de formação em cadeia, este número de horas investidas cai para cerca de 5 horas semanais.

Uma vez que os alunos conhecem sobre pesquisa, esperamos passar para um nível mais alto em 2018, apenas nos dedicando ás pesquisas em revistas científicas.

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The SoS Project new student-Tutorial

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Abstract

Rejection rates, truancy and retention in engineering courses are considered high in the following semesters the student admission (40%). In academic literature there are debates about its causes: gaps in knowledge of mathematics, the commitment of the student, not teaching method with low incentive for student learning, student's ignorance about learning techniques and others. The chance for the main cause of higher rates is the ignorance and disuse of assimilation techniques and organisation of time and planning to study. From this premise was proposed the project SOS Tutoring Freshman at the University of Brasilia/College. It runs from the second half of 2013. The project has funding of scholarships by the Edict Tutoring/UnB. Its main purpose is to stimulate the skills in students that will increase/and or accelerate the cognitive ability and organizational and help him to cope with the demands of the University paper. The methodology of the project consists of: diagnosis of the form of study of the students and selection of memorization techniques appropriate to each student; assistance for preparation and adjustments of the study plan; training for work presentations, survey of bibliographic reference and writing scientific paper. The theme generator is the content of the discipline. The target audience are the students of engineering and environment. The course is offered to freshmen and consists of three classes with an average of 120 students. The data on the notes and approval in discipline shows that there was an increase in the rate of approval in the discipline in the period in which the project was executed. Already reports from students who were seen indicate that the project helped them in studies. The main objective of this work is to present the project, your methodology and its results through quantitative and qualitative data

Keywords: Education Projects; Engineering Education; Active methodology.

O Projeto SoS Calouro - Tutoria

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Resumo

As taxas de reprovação, evasão escolar e retenção nos cursos de engenharia são consideradas altas nos semestres seguintes ao ingresso do aluno (40%). Na literatura acadêmica existem debates sobre as suas causas: lacunas no conhecimento de matemática, o não comprometimento do aluno, método de ensino com baixo estímulo para o aprendizado do estudante, desconhecimento do aluno sobre técnicas de aprendizagem e outros. A hipótese para a principal causa das taxas altas é o desconhecimento e desuso de técnicas de assimilação e organização de tempo e planejamento para estudar. A partir dessa premissa foi proposto o projeto SOS Calouro Tutoria na Universidade de Brasília/Faculdade Gama. Esse projeto é executado desde o segundo semestre de 2013 e tem financiamento de bolsas pelo Edital Tutoria/UnB. O principal objetivo é estimular as habilidades nos discentes que aumente acelere acontribuir para acelerar e, ou aumentar capacidade cognitiva e organizacional ajude o estudante a enfrentar as demandas do seu papel de universitário. A metodologia do projeto consiste em: diagnóstico da forma de estudar dos alunos, identificação e seleção de técnicas de memorização; auxílio para elaboração e, ou reajustes de plano de estudo; treinamento para apresentação de trabalhos, ensino de levantamento de referencial bibliográfico e redação de artigo científico. O tema gerador é o conteúdo da disciplina. O público alvo são os discentes de Engenharia e Ambiente. A disciplina é ofertada aos calouros e constituída por três turmas, com uma média de 120 alunos por turma. Os dados sobre as notas e aprovação na disciplina demostram que ocorreu um acréscimo na taxa de aprovação na disciplina no período em que o projeto foi executado. Já os relatos dos alunos antigos que foram atendidos indicam de que o projeto os ajudou nos estudos. O principal objetivo desse trabalho é apresentar o projeto, sua metodologia e seus resultados por meio de dados quantitativos e qualitativos

Palavras-chave: Projetos de ensino; Educação em engenharia; metodologia ativa.

1 Introdução

O direito e a oportunidade na educação com equidade social é utópico no Brasil. A educação não é democrática. A desigualdade é inegável. Se a desigualdade de acesso à educação é notória quanto mais a qualidade nas instituições públicas? O que pode significar qualidade em educação? O rendimento escolar? Os indicadores gerais de educação? O ideal é a qualidade seja no mínimo intraescolar com boa estrutura predial, instalações, estrutura organizacional, ambiente escolar e relações intersubjetivas no cotidiano escolar. Se sistema brasileiro de educação está longe de ser democrático e significar equidade social, como tratar o discente calouro no ensino superior que traz várias lacunas de conteúdo em sua formação?

A desigualdade social, a carência de conteúdos aliada a outros fatores contribuem para a reprovação, evasão escolar e retenção no ensino superior. Reprovação escolar indica que nota obtida pelo aluno em uma disciplina não é satisfatória. Evasão é quando o aluno abandona a instituição de ensino. Retenção é quando o aluno não está no fluxo das disciplinas de seu curso, devido a reprovação, abandono, trancamento ou não se matriculou.

De forma ampla pode-se dizer que os principais problemas da educação no Brasil são: evasão e reprovação escolar. No entanto, debater sobre eles requer reconhecer a complexidade dos mesmos. A análise da complexidade da evasão escolar no ensino superior deve ser no seu contexto histórico. Ela é resultante dos níveis anteriores de ensino cursado pelo aluno e também das dificuldades financeiras (SANTOS e LOPES, 2011).

Os principais motivos para a evasão escolar no ensino superior são: questão financeira e o desempenho acadêmico; a desigualdade social; interrupção no ciclo de estudos, falta de orientação vocacional, imaturidade do estudante, reprovações sucessivas, dificuldades financeiras, falta de perspectiva de trabalho, ausência de laços afetivos na universidade, ingresso na faculdade por imposição familiar, casamentos não planejados e nascimento de filhos; a falta de identidade com o curso; escolha errada da carreira; desencanto com a universidade; baixa demanda pelo curso, possivelmente associada ao baixo prestígio social do curso escolhido, entre eles, as licenciaturas; o precoce de ingresso do aluno no mercado de trabalho, ou as dificuldades encontradas em razão das condições desfavoráveis de currículo escolar, professores e organização da escola (SANTOS e LOPES, 2011).

Para o novo egresso universitário os dois primeiros anos constituem um periodo desafiador e exige capacidade de adaptação e integração no novo ambiente. A transposição do Ensino Médio para o Superior dependerá do psicossocial do discente e dos mecanismos disponibilizados pela universidade para auxília-los (CUNHA & CARRILHO, 2005). A evasão resulta em perda para sociedade, tanto de recursos, como de tempo de todos envolvidos no processo de ensino.

Os procedimentos metodologicos no ensino superior diminuem o paternalismo e cobrança do ensino médio. Na universidade se exige dos alunos a responsabilidade, liberdade e maturidade. As exigências do ensino, adequação do aluno as novas regras institucionais e convivio social fazem parte do desafio.

Nos cursos de engenharia foram sintetizados os principais fatores: 1) psicológicos – escolha equivocada do curso e dificuldades psicológicas; 2) formação – lacunas no conhecimento básico do ensino médio e fundamental, dificuldade para o desenvolvimento do pensamento científico; 3) currículo do curso - nível de exigência elevado, grande número de disciplinas, falta de tempo para estudar, muitas provas e trabalhos, prazos apertados, falta de integração entre disciplinas, carga horária excessiva, defeitos da grade curricular, falta de tempo para atividades físicas, sociais e culturais, desatualização curricular em razão do avanço científico e tecnológico; 4) pedagógicos e estruturais: deficiências pedagógicas na formação de professores e coordenadores, mudanças do paradigma educacional e deficiências de recursos e infraestrutura do curso (THOMAS et al, 2011).

O principal objetivo desse trabalho é apresentar o projeto SoS-Calouro no contexto da evasão escolar e metodologia ativa em sala de aula, em especial no quesito de ensino-aprendizagem para estimular a mudança da atitude do aluno engresso quanto a postura de disicente de ensino médio para universitário.

2 Objetivo e metodologia do projeto SoS Calouro - Tutoria na UnB

O projeto ocorre na disciplina de Engenharia e Ambiente na Faculdade Gama/UnB ofertada no ciclo básico aos cursos de Energia, Software, Aeroespacial, Automotiva e Eletrônica. Na disciplina existem três turmas grandes, em média com mais 100 alunos, e com professores diferentes. O objetivo geral da disciplina é promover um despertar no discente para uma visão holística de mundo e mudanças de bons hábitos educacionais pelo estudo da relação entre as práticas da engenharia e o meio ambiente, evidenciando as tecnologias e as potencialidades e fragilidades ambientais por meio do seu desenvolvimento intelectual. Nos últimos quatro semestres a metodologia se fundamenta em uma mescla de técnicas didáticas. A disciplina engenharia e ambiente que tem como instrumentos de avaliação as atividades de elaboração e resolução de exercícios, apresentação e debates sobre conteúdos por grupos, elaboração de mini-artigo científico de revisão teórica e provas.

O projeto Tutoria-SOS Calouro existe desde 2014 ao dias atuais. Ele tem por objetivo acolher e motivar os alunos novos e repetentes para se dedicar aos estudos, buscando as suprir as suas deficiências em conteúdo necessários para cursar engenharia na universidade, por meio de orientações e apoio para execução de suas atividades, almejando a o seu sucesso.

Em 2017 ele foi executado na turma B com 127 alunos, um monitor e quatro tutores. Sua operacionalização é feita pelos tutores e monitores. O monitor está presente em todas as aulas e faz a interface entre o docente, tutores e alunos. Logo, ele está cadastrado na turma virtual no sistema de ensino à distância. No segundo semestre de todos os anos o projeto tem financiamento de bolsas pelo Decanato de Graduação. Sua metodologia consiste no acolhimento e integração universitária, bem como o apoio à aprendizagem em fases apresentadas na Figura a seguir.

1) **Diagnóstico sobre as formas de estudos e aprendizagem dos alunos** – nas primeiras semanas de aula é solicitado ao aluno que preencha um questionário em ambiente virtual.
2) **Diagnóstico Elaboração de um plano de estudo** – o primeiro plano de estudo é construído pelo aluno à sua maneira, sem explicações. O segundo é elaborado com o tutor e seundo o diagnóstico individual de cada aluno.
3) **Apresentação sobre os direitos e deveres dos universitários** – usa-se o manual do aluno para dar ciência sobre a nova condição do discente como universitário. Enfatiza-se a importância da distribuição das ações da Universiade de ensino, pesquisa e extensão. Solicita-se ao aluno que responda algumas perguntas, inclusive sobre desligamento e religamento do aluno. Também é pedido para o aluno fazer seu cadastro e currículo na base lattes;
4) **Cadastro no lattes** - os alunos fazem seus cadastros na base capes;
5) **Oficina de levantamento bibliográfico em bases científicas** – com ajuda da bibliotecária da FGA é realizado uma aula sobre como fazer uso das bases científicas disponíveis na Biblioteca Central, em especial de revistas indexadas. A seguir é pedido a cada aluno que busque e faça um fichamento de um artigo de relevância de um determinado assunto, em geral o assunto do tema do seu grupo de sala de aula a ser apresentado em sala de aula;
6) **Oficina de uso de ferramentas para biblioteca digita**l – os alunos aprendem a usar o Endnote e Mendley;
7) **Oficina para apresentação de conteúdo em eventos científicos** – é feito um treinamento sobre apresentação científica que considera contato visual com o público; no item voz será levada em conta, a dicção, altura da voz, vocabulário culto na área do assunto e uso de linguagem apropriada; a preparação do orador é correta quando a velocidade da voz e as transições das partes da apresentação são realizadas tranquilamente; o ritmo é o mesmo sem pausa ou aceleração na velocidade da explicação; o recurso audiovisual mostra cores harmoniosas, mensagens claras, fáceis de ler, objetivas e o apresentador consegue fazer suas explicações com conhecimento no momento da arguição com o público. Cada grupo de alunos fará uma apresentação sobre o assunto do seu grupo e utilizará os artigos científicos já levantados. A apresentação será exposta em sala de aula;
8) **Elaboração de perguntas para estudos** – cada grupo fará elaboração de perguntas para compor os estudos dirigidos que serão aplicados à distância aos outros colegas. Durante um dia específico, o monitor resolve presencialmente os exercícios elaborados pelos grupos dos temas das apresentações. Essas questões são questões específicas que só são capazes de responder quem estuda o referencial bibliográfico. Dessa forma, os alunos são obrigados a entrar em contato com a bibliografia para encontrar a resposta exatamente segundo a visão do autor do livro. A interação entre os alunos promove a ajuda dos que têm mais facilidade aos que têm mais dificuldade. Qualquer dúvida não resolvida pode ser dirigida ao monitor e caso ele não consiga solucionar pode ser direcionada à docente da disciplina.
9) **Apresentação de técnicas de memorização** – são apresentadas as técnicas de memorização mais usuais pelos alunos, os resultados do diagnóstico sobre o uso de técnica de memorização da turma. A seguir são apresentadas as técnicas mais eficazes. Cada aluno escolherá uma técnica que utilizará durante o semestre;
10) **Elaboração de planos de estudo individuais** – a partir da grade horária todos os alunos elaboram seus planos de estudos;
11) **Acompanhamento dos "padrinhos tutores"** - Revisão dos planos de estudos - os alunos que tiveram nos testes notas abaixo de 50% são convocados para ir ao atendimento tutoria e refazerem seus diagnósticos e planos de estudos. A ideia é o aluno identificar qual a sua dificuldade e encontrar estratégias para superá-las. Os encontros são diários no horário do almoço, que é um horário livre e cômodo para os alunos;
12) **Criação de grupos de estudos** – os grupos de estudos são criados nos fóruns virtuais. O ambiente torna-se propício de estudo, onde ajuda na memorização da matéria, por terem que escrever as perguntas e procurar pelas respostas. Assim, deixa com que os alunos estejam muito mais preparados para a segunda e terceira avaliação da disciplina;
13) **Oficina de redação de artigo científico** – técnicas de como elaborar um artigo científico. Cada participante receberá um artigo (word) que foi elaborado por outro grupo e um formulário de avaliação do artigo. Em 24 hora ele entregará o formulário preenchido e seu comentários no documento em word. A seguir cada participantes receberá o artigo de seu grupo, comentando e com a ficha de avaliação. Em 24 horas ele enviará uma nova versão do artigo de seu grupo. Os membros de cada grupo se encontram e produzem um único artigo científico a ser avaliado com trabalho final da disciplina. A discussão sobre o conteúdo de cada grupo é feita no artigo científico onde os alunos confrontam o referencial bibliográfico da disciplina com os que foram pesquisados por eles.
14) **Divulgação da universidade pública** – os grupos fazem apresentações nas escolas públicas e relatam as suas experiências no contexto universitário com o tema “É possível sonhar”. Enfatizam as facilidades como bolsas e o projeto “pirraça” que é de preparação gratuita para o vestibular com aulas dadas por alunos voluntários. O público alvo principal são as meninas.

Figura 1: Quadro metodológico do projeto Tutoria

A aplicação dos formulários para diagnóstico é feita no inicio do semestre, nas três turmas de Engenharia e Ambiente com uma média de 360 alunos. Abrange todos os alunos ingressos.

Os formulários e os planos de estudo são salvos em arquivos digitais para serem analisados durante o momento de orientação educacional individual.

Os resultados individuais destacam o método de aprendizagem do aluno e facilitam identificar a sua habilidade de registro na memória.

3 Resultados e discussões do projeto SoS Calouro-Tutoria na UnB

O principal resultado do SoS-Tutoria é despertar no discente para uma visão holística de mundo e aquisição de bons hábitos educacionais. Adotar novos comportamentos é desafiador. Costumes que os alunos tem desde ciclo básico, há mais de uma década são difíceis de serem abandonados. Incentivar e convencer o discente a modificar seus hábitos de estudo requer criatividade e persistência. A demonstração dos resultados da identificação de como o aluno estuda é imprescindível para que ele seja capaz de perceber a deficiência de seu método. Nesse trabalho destaca-se o ponto relevante das técnicas utilizadas pelos alunos para estudarem e os indicadores educacionais de avaliação do projeto.

O diagnóstico sobre as formas de estudos e aprendizagem dos alunos teve como argumento que a eficiência de técnicas de aprendizagem considerada é a razão entre o tempo gasto e a taxa de assimilação do conteúdo.

A classificação da eficiência dos métodos pode ser baixa (fazer resumo, releitura, grifar e desenhar), moderada (elaboração de perguntas, estudo intercalado com outras disciplinas) e alta (auto-explicação, testes, revisão semanal) (Dunlosky et. al. 2013). Seu resultado mais importante foi o uso de técnicas e o desempenho dos alunos na disciplina engenharia e ambiente.

A freqüência da variável uso de técnicas de memorização no período 2014-2 a 2017-2 indicam que a maioria dos alunos (entre 71% e 54%%) estuda com a utilização de técnicas menos eficiente de assimilação de conteúdo (Figura 2).

Quanto ao tempo dedicado aos estudos na UnB/FGA os alunos devem cursar no mínimo 16 créditos por semestre equivalente 16 horas semanais em sala de aula. Os dados do diagnóstico indicam que o tempo dos alunos dedicado em estudos extra classe é variável. No universo amostral os alunos estudam em média 16,7 horas por semana, ou seja, 2,4 horas em 7 dias ou 3,3 horas em 5 dias. O valor de 16,7 horas por semana equivale a 55,7% das 30 horas semanais em sala de aula. A soma de estudo em classe e extraclasse é a carga horária semanal de estudo de 46,7 horas com 6,7 para 7 dias ou 9,3 horas em 5 dias.

A eficiência extraclasse foi calculada pela razão entre a média mínima de horas necessária para estudo de engenharia (30 horas/semana) pelo total de média de horas estudadas pelos alunos por semestre (Vide Figura 3).

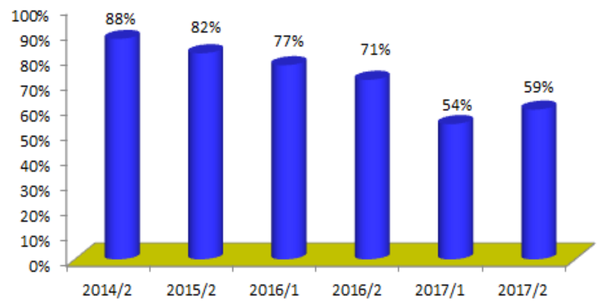

Figura 2: Percentual de alunos que estudavam com o uso de técnicas de baixa eficiência (2014 a 2017).

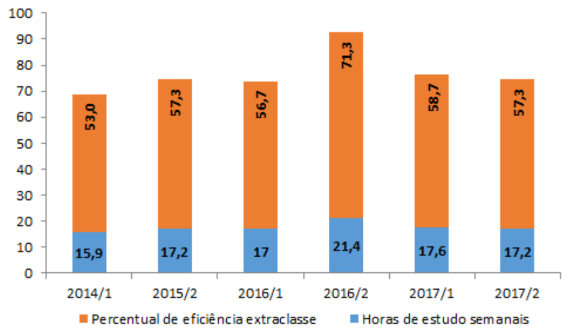

Figura 3: Eficiência extraclasse (2014, 2015, 2016 e 2017)

Também observou-se as outras variáveis de boas práticas de estudo extra classe: 81% estuda a noite; 44% estuda entre 3 horas/diária ou mais; 44% sempre estuda nos finais de semana com 27% em 3 a 4 horas; 62% faz pausa de 30 a 60 minutos nos estudos; 19% revisa o conteúdo no mesmo dia da aula; 55% faz os exercícios recomendados pelo professor.

Chama-se a atenção para algumas curiosidades para os resultados do diagnóstico na turma B em 2017/1. A maioria do alunos fazem os exercicios (55%), estudam em casa (86%), tem iluminação moderada no ambiente de estudo (64%) e usam como método de memorização a resolução de exercicios (91%) e ler e reler o assunto no mesmo dia (18%) em que estudou o assunto em sala de aula (vide Figura 4).

A maior parte (de 88% a 54%) dos novos egressos na FGA utilizou técnicas de baixa eficiência (Figura 2), isso leva a suspeita de que os alunos dos ensinos básico e médio tenham carência ou ausência de orientação educacional adequada para estudar com eficiência.

No diagnóstico das formas de estudos e técnicas de aprendizagem dos alunos identificou-se que os novos discentes quando iniciaram o semestre utilizavam várias técnicas de memorização. O predomínio foi de técnicas de baixa eficiência. Um novo diagnóstico realizado depois dos alunos participarem do projeto SOS-Calouro Tutoria mostrou que eles passaram a fazer uso de técnicas de estudo de maior eficiência. Isso pode ter contribuído para um melhor desempenho da turma na taxa de aprovação na disciplina.

O desempenho do aluno nos primeiros semestres na universidade está vinculado a sua capacidade de desenvolvimento do pensamento cientifico, gestão do seu tempo dedicado aos estudos e interesse individual.

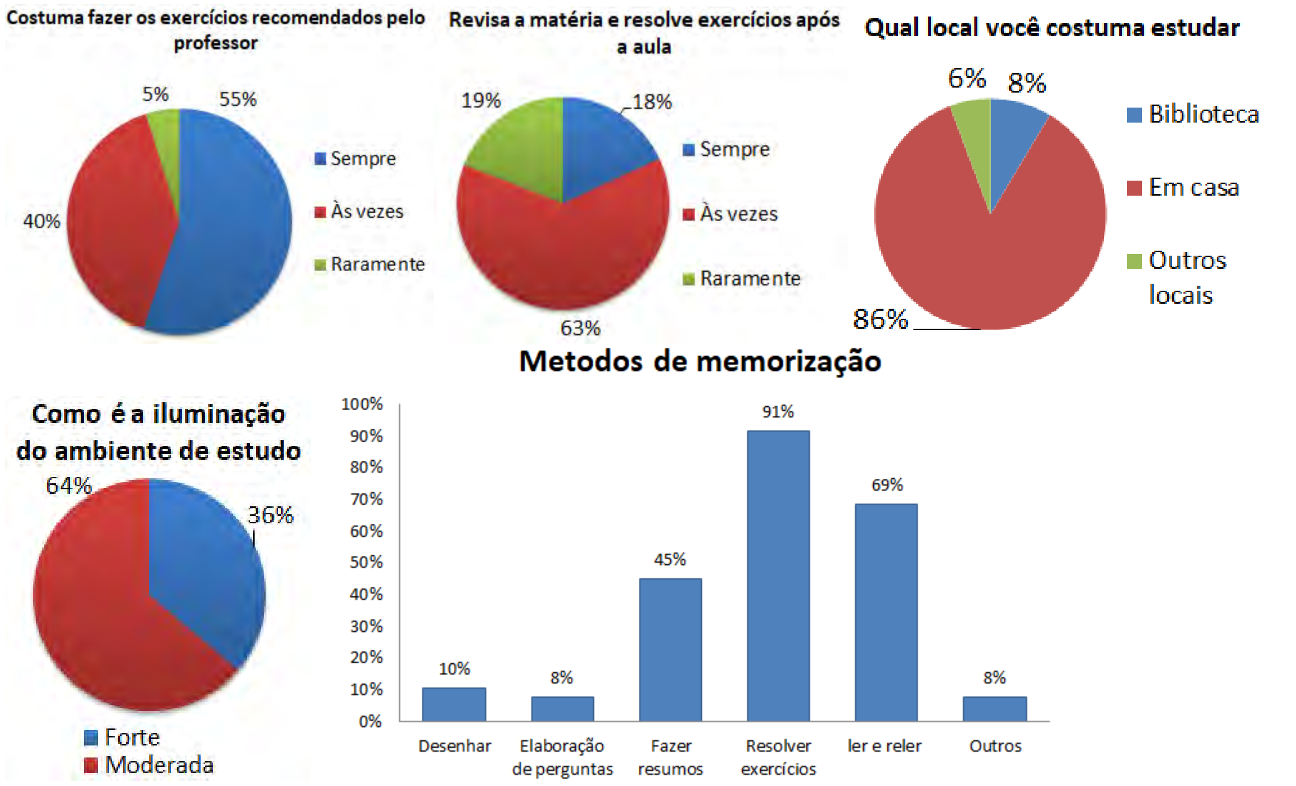

Figura 4: Resultados dos diagnóstico da turma B em 2017/1.

Acredita-se que existem falhas na orientação desde o ensino infantil ao ensino médio. As exigências no ensino superior, o tempo disponível e a dedicação dos novos egressos contribuem para o estress dos alunos levando-os a reprovação, retenção, evasão e desligamentos na FGA.

Em relação aos indicadores de avaliação do projeto SOS Calouros Tutoria considerou-se as taxas de reprovação, evasão e abandono, em especial na turma B, onde o projeto foi executado com todas as suas fases. A turma B teve um universo amostral anual mostrado na Figura 5. Também notou-se que houve uma queda de 89% nos valores do indicador de reprovação ao longo dos anos. Destaca-se que o método começou a ser aplicado no 2º semestre de 2014. Nota-se entre os dois semestres de 2014 uma redução de 25% na taxa de reprovação. Talvez esse resultado seja também ao inicio do projeto em no segundo semestre de 2014. Quanto as taxas de evasão e abandono pode-se afirmar que ela teve uma variação bruta de -5.

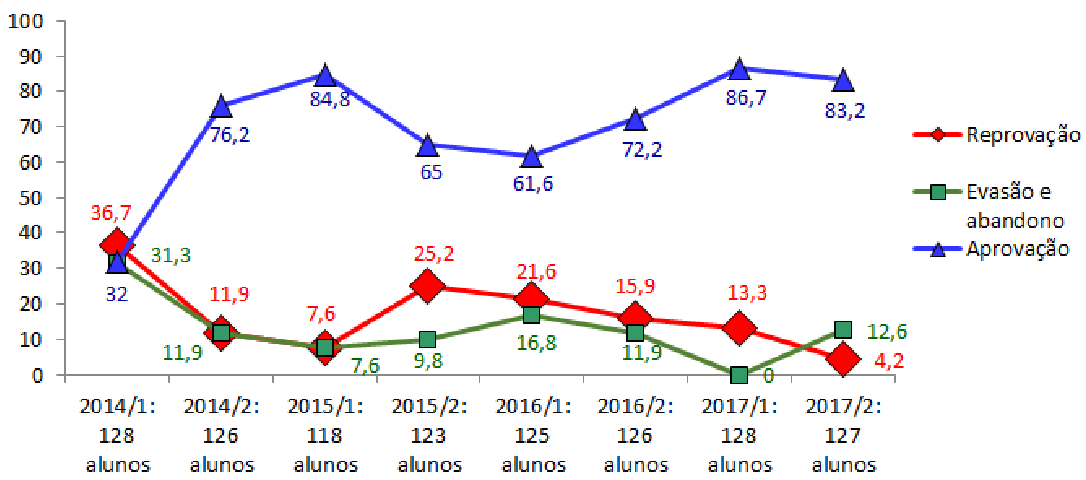

Figura 5: Indicadores educacionais de Reprovação, Aprovação e Evasão e Abandono (2014 a 2017).

Quanto as atividades de tempo dedicado aos estudos, considera-se como parâmetro ideal que o aluno realize estudo extraclasse com o mesmo número de horas de sala de aula. Isso equivale 30 horas por semana, 6 horas em 5 dias ou 4 horas em 7 dias. No entanto, o mínimo de estudos extraclasses em média pelo universitário brasileiro é de 6 horas por semana e menos de cinco horas semanais (CARELLI e SANTOS, 1998). Notou-se que os alunos da FGA tem essa prática. Logo, presume-se que o tempo gasto é normal, no entanto com baixa eficiência de assimilação.

No diagnóstico das formas de estudos e técnicas de aprendizagem dos alunos identificou-se que os novos discentes quando iniciaram o semestre utilizavam várias técnicas, com predomínio de técnicas de baixa eficiência. Um novo diagnóstico realizado depois dos alunos participarem do projeto SOS-Calouro Tutoria mostrou que eles passaram a fazer uso de técnicas de estudo de maior eficiência. Isso pode ter contribuído para um melhor desempenho da turma na taxa de aprovação na disciplina.

O projeto tem como força o financiamento da UnB e ser aplicado em turmas grandes de calouros. Tem como oportunidade o despertar para a transformar de visão e comportamento dos tutores e alunos com provável aumento de qualidade e quantidade de discentes formados. Fortaleza tem a parceria entre a direção e decanato de graduação e preocupação dos discentes com a qualidade do curso. Fraqueza é o impedimento ter alunos voluntários com Indice de Rendimento Acadêmico abaixo de 3. Ameaças estão ligadas à dificuldade de espaço disponível na FGA.

Pode-se dizer o projeto SOS calouro tutorial está no contexto da metodologia ativa. As atividades realizadas no âmbito do projeto estimulam o desenvolvimento de habilidades como autonomia, criatividade, responsabilidade e iniciativa (RICHARTZ, 2015). Durante o projeto o papel do docente é municiar o discente de ferramentas que podem torná-lo autodidata com condições de observar, estudar, aprender, comparar, relacionar, analisar, levantar hipóteses e argumentar. O aluno tem a oportunidade de mudar suas práticas de estudo e ser uma pessoa com condições de conseguir mais discernimento sobre os assuntos estudados na universidade. Acredita-se que a metodologia ativa pode ser uma das formas de melhorar as relações intersubjetivas nas instituições de ensino superior.

Entende-se que o papel do professor no processo é criar situações e condições para que o aluno possa observar, experimentar, comparar, relacionar, analisar, levantar hipóteses e argumentar (MIZUKAMI, 1986). Na avaliação são esperadas explicações práticas com expressões próprias do aluno.

Nesse contexto afirma-se que o ser humano constrói seus conceitos e significados pautados nas suas vivências nos mundos em que ele está inserido. Assim são construídas as relações do eu com tu. O subjetivo do ser é complexo constituído também de ideologias e valores. As relações intersubjetivas são internas do sujeito. No contexto institucional essas relações são construídas por aqueles que convívio diário no âmbito da instituição. O conhecimento, requer processos de construção e reconstrução de saberes mediante a ação do sujeito sobre o ambiente e pela relação intersubjetiva mediada pela linguagem. Entende-se como intersubjetividade a relação entre sujeito e sujeito e/ou sujeito e objeto (BUBER, 1992; CAMARGO et SANTOS, 2010).

4 Conclusão

Inúmeros trabalhos existem sobre as causas do problema da quantidade de ingressantes na educação e formandos no ensino básico, médio e superior. No ensino superior os serviços de orientação e supervisão educacionais são quase inexistentes. Existe a necessidade de orientação para que os alunos adotem bons hábitos de estudos. Os discentes “sentem” a mudança dos processos educacionais e raros tem planejamento para estudar com responsabilidade de seguir os horários de estudo.

Planejar o estudo vai além da distribuição do tempo semanal, ou seja, horas de estudo. Compreende na verdade a busca de um estudo eficiente, onde são consideradas as habilidades dos alunos para o estudo, a técnica utilizada e o ambiente adequado. Quando o planejamento é inexistente pode causar impacto negativo no desempenho do estudante.

É dispensável que os docentes nos cursos de engenharia tenham formação pedagógica nos concursos públicos e na prática diária em sala de aula. A qualificação dos docentes das instituições em ensino superior predomina a exigência de artigos científicos em detrimento à função principal, ser Educador. A busca por qualidade educacional está além do ingresso, permanência e conclusão de um curso. As medidas para melhorá-la tem como base a identificação das condicionantes da política de gestão, reflexão e propostas estratégicas de modificação do quadro atual, em especial na educação básica.

Assim, conclui-se que o projeto SoS Calouro Tutoria alcançou o sucesso almejado. Os índices de reprovação e evasão decresceram. É válido a aplicação de novos métodos de aprendizagem, que faz com que os alunos despertem suas habilidades para obter novos conhecimentos com eficiência na aprendizagem.

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Active methodologies applied to the Brazilian context: development of an observation laboratory to disseminate best practices

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Abstract

The professional market has demanded a more dynamic and proactive profile of young graduates. Universities, increasingly attentive to the characteristics demanded by the market, propose active learning methodologies in order to work the competencies consonant with this demand. The experience that the course of Production Engineering of the University of Brasília has acquired through active methodologies favors a learning curve adept to the real problems coming from the Brazilian society. However, continuing to advance the methodology requires a channel of constant communication between the market and academia, in order to integrate the new perspectives of active methodologies and the needs of society. Scientifically, studies on active methodologies, specifically Problem Based Learning (PBL), are growing. From a survey of the literature, 653 works on PBL were found in Engineering. However, the environment of each University can be decisive in relation to the practices, which may or may not be compatible with its reality. This article focuses on researching the main practices of active methodologies, proposing steps for the development of an observatory that presents an environment for replication of advances in the area. The research is structured in three stages: systematic bibliographic research using the Theory of Consolidated Meta-Analytic Approach (TEMAC); mapping of the phases contained in the main methodologies identified in the literature and that are adequate to the reality of RPE; and making these methods available online for teacher use and feedback. As a result, the PBL methodologies are expected to be communicated from a broad perspective, involving the academy that proposes solutions, the student, who must feel engaged, the teacher, who must have the enabling conditions to apply these methodologies, so that facilitate their space of communication with the student, and the market, when perceiving skills and knowledge adhering to the current needs.

Keywords: Active Methodologies; Problem Based Learning; Observatory

Metodologias ativas aplicadas ao contexto brasileiro: desenvolvimento de um laboratório de observação para disseminação das melhores práticas

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Abstract

O mercado profissional tem exigido dos jovens egressos um perfil mais dinâmico e proativo. As universidades, cada vez mais atentas às características requisitadas pelo mercado, propõem metodologias de aprendizagem ativas no sentido de trabalhar as competências consoantes com essa demanda. A experiência que o curso de Engenharia de Produção da Universidade de Brasília tem adquirido por meio das metodologias ativas favorece uma curva de aprendizagem adepta aos problemas reais advindos da sociedade brasileira. Porém, continuar avançando na metodologia requer um canal de comunicação constante entre o mercado e a academia, com a finalidade de integrar as novas perspectivas de metodologias ativas e as necessidades da sociedade. Cientificamente, os estudos sobre as metodologias ativas, especificamente o *Problem Based Learning* (PBL) estão em crescimento. A partir de um levantamento da literatura, foram encontrados 653 trabalhos sobre PBL na Engenharia. Porém, o ambiente de cada Universidade pode ser decisivo em relação às práticas, que podem ser compatíveis ou não à sua realidade. Esse artigo tem como foco pesquisar as principais práticas de metodologias ativas, propondo etapas para o desenvolvimento de um observatório que apresente um ambiente para réplica dos avanços na área. A pesquisa está estruturada em três etapas: pesquisa bibliográfica sistemática utilizando a Teoria do Enfoque Metaanalítico Consolidado (TEMAC); mapeamento das fases contidas nas principais metodologias identificadas pela literatura e que se adequam à realidade do EPR; e disponibilização destes métodos em plataforma *online* para uso dos professores e posterior *feedback*. Espera-se como resultados, comunicar as metodologias PBL desde uma perspectiva ampla, onde envolva a academia que vem propondo soluções, o discente, que deve sentir-se engajado, o docente, que deve possuir condições facilitadoras para aplicar estas metodologias, de modo que facilitem seu espaço de comunicação com o aluno, e o mercado, ao perceber competências e conhecimentos aderentes às necessidades atuais.

Keywords: Metodologias Ativas; Aprendizagem baseada em Projetos; Observatório.

1 Introdução

O atual cenário da educação está marcado pelo dinamismo das ações voltadas a garantir a participação dos alunos nas atividades relacionadas ao ensino, pesquisa e extensão. Acompanhar os avanços relacionados às metodologias ativas é garantir uma reflexão mais profunda dessas ações e divulgação de boas práticas. O curso de Engenharia de Produção da Universidade de Brasília está pautado na metodologia de aprendizagem baseada em projetos (PBL), e utiliza sete disciplinas de Projetos de Sistemas de Produção (PSPs) como a espinha dorsal, do quarto ao décimo semestre do curso. As disciplinas de PSPs tem como intuito desenvolver no aluno competências transversais, tais como liderança, gerenciamento, proatividade, além das competências técnicas adquiridas ao longo do curso.

A Educação Superior tem se deparado com um grande desafio de manter os estudantes motivados e engajados. O *Problem Based Learning* – PBL, tem sido utilizado como um método de ensino efetivo e como uma alternativa a esse desafio. Não basta ter um conhecimento básico e fragmentado com atividades simples e repetitivas. Busca-se um cenário onde a educação trabalhe atividades complexas e variadas, no intuito de atender a diferentes interesses, habilidades e necessidades dos estudantes, com participação e colaboração. O foco do PBL é incentivar a execução de atividades proativas, sem comprometer o conhecimento e as habilidades básicas Gómez-Pablos et al (2017).

O PBL, utiliza a problematização como estratégia de ensino-aprendizagem. Esta estratégia de ensino utilizada pela UnB em seu curso de Engenharia de Produção estimula o aluno a buscar o conhecimento, uma vez que ele propõe soluções para os problemas reais provenientes dos agentes externos. O PBL pode ser aplicado em várias áreas das engenharias Sunaga et al (2017)

O estudante passa a ser o sujeito do processo de aprendizagem, pois a sua aprendizagem depende da busca constante pelo conhecimento acerca das novas tecnologias, métodos, técnicas e ferramentas que podem ser utilizadas na condução das atividades para a entrega das possíveis soluções. Sem embargo, apesar dos avanços nas pesquisas a respeito de metodologias ativas, as iniciativas realizadas pelo curso de Engenharia de Produção nos últimos anos demandaram adaptações para atender melhor às necessidades dos discentes e do curso.

A experiência de Engenharia de Produção favoreceu uma curva de aprendizagem aderente à realidade brasileira. Porém, continuar avançando na metodologia requer um canal de comunicação constante entre o mercado e a academia, com a finalidade de integrar as novas perspectivas de metodologias ativas e as necessidades da sociedade. Cientificamente, é um tema em crescimento conforme pesquisa realizada na Web of Science, base de dados considerada a mais relevante cientificamente.

Diante desse contexto, surge a seguinte problemática: "De que forma pode-se estabelecer um mecanismo de comunicação entre a sociedade e a academia, visando, por um lado, fortalecer o conhecimento dos alunos, mediante a prática do PBL, e por outro lado, proporcionar benefícios para a sociedade, por meio de projetos desenvolvidos pelos alunos de Engenharia de Produção"?

A fim de responder a essa questão, a seguinte pesquisa propõe estruturar um observatório que possibilite compreender os avanços das metodologias ativas, identificar as demandas da sociedade e intensificar as soluções propostas pelos alunos, por meio da utilização do PBL no curso de Engenharia de Produção. Além disso, visa divulgar o trabalho realizado pela academia e estreitar os laços com as instituições que tenham interesse em aprimorar seus processos de negócio, por meio de soluções via projetos.

Esse artigo está estruturado em 5 seções. A seção 2 apresenta o referencial teórico sobre metodologias de aprendizagem ativa, especificamente aprendizagem baseada em projetos. Na seção 3 é mostrada o método de pesquisa. A seção 4 exibe a estruturação do observatório e a seção 5 traz as conclusões.

2 Problem based learning (PBL)

A partir de um levantamento da literatura, na base de dados *Web of Science*, foram encontrados 5236 trabalhos sobre *Problem-based Learning* (PBL), sendo que sua aplicação em Engenharia conta com 653 trabalhos, e 98 deles publicados no periódico *International Journal of Engineering Education*. O Brasil é o quarto país que mais publicou sobre o tema com 31 trabalhos de impacto e 2016 foi o ano com maior número de publicações levando em consideração os últimos 20 anos, deixando claro o interesse sobre essa área.

De acordo com Ergül & Kargin (2014), as características da abordagem de aprendizagem baseada em projetos (PBL) são: os estudantes constroem e direcionam sua própria aprendizagem, trabalham de forma criativa, resolvem problemas em cooperação. O eixo principal dessa metodologia é o aprendizado com base no desenvolvimento de projetos, em que o objetivo é entregar produtos concretos.

O trabalho baseado em projetos na sala de aula propicia aos estudantes o desenvolvimento de tarefas desafiadoras e complexas, promovem a auto avaliação, estimulam a aprendizagem colaborativa e cooperativa, em que os estudantes se tornam pesquisadores capazes de estabelecer hipóteses, compreender e experimentar situações da vida real, tendo um impacto na motivação e no desempenho acadêmico. Portanto, a base do PBL é a experimentação da vida real. Os estudantes trabalham em equipe para responder a uma questão direcionada, e geram um produto que mostra o conhecimento adquirido na resolução do problema. Esses produtos podem ser entregues por meio de mídias, relatório escrito, vídeos, fotografias ou apresentações que utilizam a tecnologia Gómez-Pablos et al (2017).

O ambiente de aprendizagem com base no PBL facilita a resolução de problemas e o pensamento crítico. Muitas universidades japonesas estão implementando a aprendizagem baseada em projetos (PBL), em que os estudantes adquirem expertise, conhecimento e habilidades, com atuação em projeto com prazo bastante restrito em cursos de engenharia de software e outras engenharias (Sunaga *et al.*, 2017).

2.1 Aplicabilidade de *Problem based learning* (PBL) nas Engenharias

Existem três características que devem ser abordadas no PBL, a saber: i) a abordagem deve ser orientada a processos. Com a visão do processo, os conhecimentos e habilidades, adquiridos ao longo do processo de desenvolvimento do projeto, impulsionam atividades que culminam na entrega de um produto final, ii) estar relacionada ao contexto. O projeto desenvolvido envolve colaboração real dos estudantes na resolução prática de problemas relacionado ao contexto estudado, e iii) ser centrada no aluno. Os alunos são obrigados a participar ativamente dos projetos, aprendendo a tomar decisões mediante as alternativas de execução de uma determinada tarefa, e o professor atua como facilitador, criando condições necessárias para que os alunos trabalhem um com outro Chu et al. (2017). Todos os aspectos abordados pelo PBL podem ser facilmente aplicados às engenharias, que tem como natureza trabalhar na resolução de problemas.

A profissão do engenheiro exige muita criatividade e pensamento crítico para desenvolver soluções de problemas oriundos do mercado (Lima et al, 2012). Para isso, muitas universidades têm buscado novas formas de ensino e aprendizagem, a fim de que os alunos possam aprender e desenvolver suas habilidades.

A Universidade Federal do Amazonas realizou um projeto para o desenvolvimento de dispositivos móveis na disciplina de Engenharia de Software, utilizando uma combinação da metodologia baseada em problema (PBL) e a metodologia SCRUM. Os resultados foram muito positivos, ao passo que a experiência prática dos alunos permitiu aos mesmos identificar desafios e soluções durante a realização do projeto, além de ter uma visão de como a prática em um projeto real ajuda aos estudantes a ter um melhor entendimento das teorias, práticas, métodos, processos e ferramentas que envolvem a Engenharia de Software (Meireles & Bonifácio 2015).

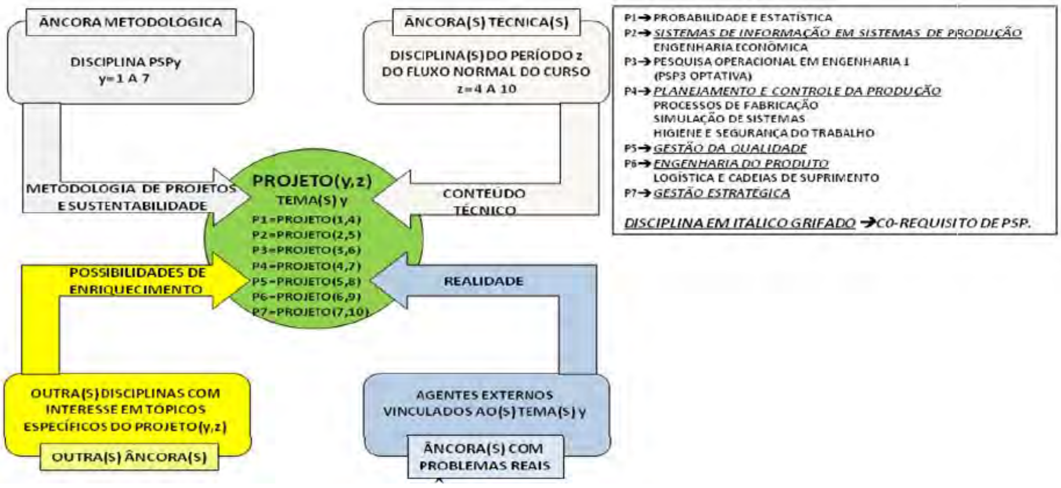
Outro exemplo de aplicação de PBL na engenharia é o da Escola de Engenharia da Universidade do Minho. São propostos desafios para os alunos do primeiro ano, que desenvolvem projetos com interface com disciplinas de Introdução à Engenharia e Gestão Industrial (Departamento de Produção e Sistemas), Programação de Computadores (Departamento de Sistemas de Informação), Química Geral (Departamento de Química) e Cálculo C (Departamento de Matemática). Segundo Campos et al (2013), na edição 2011/2012 os objetivos de aprendizagem propostos foram alcançados, a qualidade dos trabalhos esteve dentro dos padrões aceitáveis e desejáveis. As tarefas foram todas realizadas e cumpridas dentro dos prazos estabelecidos, apresentando um bom desempenho na gestão do tempo.

A seção 3 apresenta o relato do PBL aplicado ao curso de Engenharia de Produção.

3 PBL aplicado ao curso de Engenharia de Produção da UnB

Monteiro *et al.*, (2017) apresenta que as disciplinas de Projetos de Sistemas de Produção (PSPs) estão baseadas em quatro âncoras principais: âncora metodológica que abarca a metodologia de projetos com enfoque em sustentabilidade; disciplinas de conteúdo técnico que fornecem a base para a execução dos projetos; agentes externos *(stakeholders*) que apresentam problemas reais, que podem ser tanto empresas públicas quanto privadas; e outras disciplinas, que contemplam outras áreas de conhecimento, com interesses em tópicos específicos do projeto. A Figura 1 mostra a integração das disciplinas de PSP com as âncoras.

Figura 1: Esquema Geral de Âncoras para Projetos (y,z) de Sistema de Produção



Fonte: Monteiro et al (2017)

De acordo com a Figura 1, os resultados oriundos dos projetos desenvolvidos nas disciplinas de PSP, que adotam o PBL, resolvem problemas de agentes externos, vinculados às disciplinas âncoras técnicas, que estão compreendidas na grade do curso (PSP1 – Probabilidade e estatística; PSP2 – Sistema de Informação aplicado à Engenharia de Produção ou Engenharia Econômica; PSP3 – Pesquisa Operacional; PSP4 – Planejamento e Controle da Produção, Simulação de Sistemas ou Saúde e Segurança no Trabalho; PSP5 – Gestão da Qualidade; PSP6 – Engenharia do Produto ou Logística e PSP7 – Gestão Estratégica). Alguns exemplos de projetos desenvolvidos são: "análise exploratória de dados da situação da fila cirúrgica no Hospital Universitário de Brasília (HUB), "análise exploratória de dados da possível transformação da planta de telefone de uso público em pontos de *wi-fi* público", "desenvolvimento de uma ferramenta tecnológica que facilite o acesso às informações referentes ao transporte público para os alunos da UnB", "proposta para redução de tempo de fila de espera em um consultório médico", "indicadores de qualidade para o curso de Engenharia de Produção", "elaboração de um manual de boas práticas para a implementação de um almoxarifado virtual", propostas de melhorias no sistema de entregas de uma fábrica de picolé", "critérios sustentáveis para produtos consumidos pelo Governo do Distrito Federal presentes nos eco rótulos: *Eco Mark; Green Council, EU Flower e Good Environment Choice Australia*", "projeto conceitual de um produto que identifica crise asmática em crianças de 1 a 3 anos", "máquina de impressão 3D para concreto", "estudo de implementação de uma unidade fabril de refrigeradores da linha branca". Esses resultados foram desenvolvidos nas disciplinas de PSPs.
Pode ser explicitado também no curso de Engenharia de Produção possíveis internacionalizações do conceito de PBL em disciplinas que não são de Projetos (PSPs), como já tem ocorrido em Introdução à Engenharia de Produção (IEPR), Formação de Valor em Sistemas de Produção, Metodologias de Projetos de Sistemas de Produção e Gerenciamento de Projetos Avançados. Em IEPR, uma das entregas da disciplina nesse semestre, foi realizada em Libras (Língua Brasileira de Sinais), favorecendo a inclusão na educação.

A seção 4 apresenta a metodologia adotada para o desenvolvimento da pesquisa.

4 Método da Pesquisa

A pesquisa quanto ao seu propósito é considerada exploratória, quanto à estratégia é um estudo de caso realizado no curso de Engenharia de Produção da Universidade de Brasília e quanto à abordagem é qualitativa. A técnica para coleta de dados baseou-se em documentos científicos.

Para a estruturação do observatório, é necessário primeiramente acompanhar os centros pioneiros de metodologias ativas voltadas ao PBL e os principais estudos realizados em outras esferas, que não estes grandes centros. Para isso vai ser utilizado a Teoria do Enfoque Meta Analítico Consolidado -TEMAC, de Mariano e Rocha (2017). Este método de revisão sistemática garante a integração de diversas bases de dados em resultados visuais identificando as principais escolas sobre metodologias ativas.

Em uma segunda etapa, serão realizados experimentos das melhores práticas em laboratórios das disciplinas de PSPs (Projetos de Sistemas de Produção) do curso de Engenharia de Produção da Universidade de Brasília, através do acompanhamento dos professores do Departamento, a fim de registrar resultados e possíveis adaptações realizadas para atender melhor às demandas locais.

Em uma última etapa, proceder-se-á formalização destas experiências e posterior divulgação dos resultados por meio de plataformas online e eventos específicos a serem realizados no Departamento de Engenharia de Produção.

A seção 4 detalha as etapas de estruturação do observatório.

5 Proposta de um Observatório de Metodologias Ativas (OBMA) na UnB

Esse tema único de pesquisa (desenvolvimento de um laboratório de observação para disseminação das melhores práticas de metodologias ativas) foi submetido ao Edital DEG/DAC/CEAD nº0001/2017- Programa Aprendizagem para o 3º Milênio (A3M) da Universidade de Brasília, que objetiva potencializar as iniciativas de aprimoramento no processo de ensino e aprendizagem, e na interação com os alunos, por parte dos professores. Está relacionado com outro tema que visa desenvolver uma Plataforma Unificada de Metodologia Ativa (PUMA), utilizando a Tecnologia da Informação e Comunicação (TICs), pois as informações obtidas pelo observatório serão divulgadas nesta plataforma.

A fim de atender ao propósito definido no objetivo, a pesquisa está dividida em 4 etapas, com vistas à estruturação do observatório. A Figura 2 mostra as etapas da pesquisa e os procedimentos realizados em cada etapa.

ETAPAS	PROCEDIMENTOS TÉCNICOS
• **Etapa 1**: Realizar uma revisão sistemática da literatura sobre os avanços das metodologias ativas no Brasil e no mundo	• **Procedimento 1:** utilizar métodos sistemáticos de revisão da literatura como meta-análises e índices bibliométricos
• **Etapa 2:** Integrar os avanços da literatura no desenvolvimento das soluções propostas pelas disciplinas de PSPs, com base em novos métodos e ferramentas de aprendizagem ativa	• **Procedimento 2:** por meio de réplica de melhores práticas com a ajuda de técnicas ferramentais como programas, jogos (Lego), dinâmicas (SCRUMIA), etc.
• **Etapa 3:** Divulgar os resultados obtidos na Plataforma Unificada de Metodologia Ativa (PUMA), e eventos realizados em parceria com os stakeholders que recebem as soluções das disciplinas de PSPs e potenciais stakeholders	• **Procedimento 3:** via plataforma de integração de resultados PBL e eventos realizados no Departamento EPR, que atualmente não possui evento regular
• **Etapa 4:** Elaborar artigo científico	• **Procedimento 4:** elaboração de um artigo científico, com os resultados obtidos, através do financiamento deste edital, no campo de atuação de desenvolvimento de metodologias educacionais inovadoras, por meio de consulta à bases de dados como Web of science, Scopus, etc.

Figura 2 - Etapas e procedimentos da pesquisa para a estruturação do observatório

A criação do Observatório de Metodologias Ativas (OBMA) permeia cada uma das etapas abordadas na Figura 2. A partir da identificação das melhores práticas de aplicação das metodologias ativas no Brasil e no mundo, parte-se para a análise de seus resultados, propondo soluções inovadoras, com base no que se tem adotado mundialmente, às disciplinas do curso de Engenharia de Produção que utilizam PBL. Os resultados dos projetos desenvolvidos tanto nas disciplinas de PSPs quanto nas outras disciplinas que adotam PBL são divulgados em um evento de PBL online, por meio de uma plataforma *on-line* (www.eventndo.com) denominada ENDO 2018, que é de responsabilidade dos professores do EPR, já desenvolvida, além da plataforma unificada de metodologia ativa (PUMA), que também está sendo desenvolvida e irá trazer os resultados das soluções propostas pelos alunos aos *stakeholders*.

Pretende-se unificar as melhores práticas em PBL diagnosticadas pelo observatório com as práticas desenvolvidas pelos cursos de Engenharia a nível Brasil.

6 Resultados Esperados com o OBMA

Têm-se como produtos da pesquisa a entrega de um observatório de metodologias ativas (OBMA), que é um laboratório de aprendizagem ativa (PBL) que contempla resultados oriundos das disciplinas de PSP, a fim de validar as melhores práticas, formalizando as experiências de professores, alunos e empresas parceiras. Além disso, é necessário criar eventos responsáveis por divulgar as melhores práticas validadas no observatório, discutindo experiências e possíveis aplicações de projetos na academia e com a sociedade (público alvo: interessados, pesquisadores, empresários, órgãos do governo, etc.). E por último, mas não menos importante, elaborar artigos científicos que possibilitem uma discussão com outros pesquisadores sobre a experiência do observatório.

Pretende-se por meio dos resultados obtidos com o OBMA:

- Promover a comunicação de metodologias PBL desde uma perspectiva ampla, onde envolva a academia que vem propondo soluções, o discente, que deve sentir-se engajado, o docente, que deve possuir condições facilitadoras para aplicar estas metodologias de modo que facilitem seu espaço de comunicação com o aluno, e o mercado, ao perceber competências e conhecimentos aderentes às necessidades atuais;
- Oportunizar à sociedade a divulgação dos resultados das experiências de metodologias ativas em um contexto brasileiro a assim ampliar seu uso à outros Centros de Ensino;
- Tornar o curso de Engenharia de Produção da UnB um Centro de Referência em aprendizagem ativa no Brasil, através do acompanhamento (estudo, análise, réplica, validação e divulgação) das metodologias ativas mais atuais;
- Preparar os alunos do curso de Engenharia de Produção para o mercado de trabalho, no que tange a agregar competências transversais como liderança, comunicação, gerenciamento, trabalho em equipe, adquiridas pela aprendizagem ativa (PBL).

7 Conclusão

O objetivo do artigo foi apresentar a estruturação de um Observatório de Metodologias Ativas (OBMA) para o curso de Engenharia de Produção da Universidade de Brasília que possa servir de referência aos outros cursos de Engenharia da Faculdade de Tecnologia e demais cursos de Engenharia do país.

Vale ressaltar que a divulgação do OBMA se dará de duas formas. A primeira, por meio de um evento PBL que ocorre semestralmente através de uma plataforma *on-line* (www.eventndo.com) denominada ENDO 2018, que divulga resultados PBL obtido das disciplinas de PSP para o mundo todo. A segunda, é pela plataforma unificada de metodologia ativa (PUMA) que tem o objetivo de reunir atividades relacionadas ao desenvolvimento dos projetos, avaliação dos *stakeholders*, acompanhamento da evolução das competências transversais adquiridas pelos alunos. O PUMA facilita a comunicação entre todos os agentes envolvidos no processo.

O Observatório de Metodologias Ativas (OBMA) trará uma grande contribuição científica para a academia e para a sociedade, por meio da divulgação de seus resultados.

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Professional profile and job market: analysis of the competencies of projects manager in the course of civil engineering at the University of Brasilia

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Abstract

As the market is increasingly competitive, it becomes important to identify and develop specific competencies within the individual and the organization. In the field of engineering, the project management has become a tool that exert a great influence on the company's results, highlighting the role of the project manager. Identifying the most appropriate profile of a project manager in a candidate is considered a competitive advantage for companies. Although the percentage of managers of academically-trained projects is increasing, most of the current group of project managers do not have field training throughout their undergraduate education. Most of them come from schools whose curricular program focuses mainly on calculus and technological disciplines, to the detriment of those that approach the subjects of administration and organization of production. This study aims to better understand the current situation of the competencies profile of undergraduate students of civil engineering at the University of Brasilia. To that end, 11 competences were presented in the profile of a project manager and a research was carried out together with undergraduate students from the 7th to the 10th period, through a questionnaire that evaluates the degree of perception among the 11 competences that whether or not they were developed during their training, to carry out a comparative analysis. It is noticed the lack of more than half of these competencies, leading to the questioning of how the curriculum is contributing to the formation of these future project managers. The need to revise and reformulate their curriculum is questioned, mainly due to the need to adapt the profile of the professionals who are being trained by the university to the market.

Keywords: competencies, project management, civil engineering.

Perfil profissional e mercado de trabalho: uma análise das competências de gerente de projetos no curso de engenharia civil da Universidade de Brasília

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Resumo

Devido ao mercado estar cada vez mais competitivo, torna-se importante a identificação e desenvolvimento de competências específicas no âmbito do indivíduo e da organização. No campo da engenharia, a condução e o gerenciamento de projetos tornam-se ferramentas que exercem grande influência nos resultados da empresa, destacando-se assim o papel do gerente de projetos. Identificar o perfil ideal de um gerente de projetos em um candidato passa a ser considerado uma vantagem competitiva para as empresas. Embora a porcentagem de gerentes de projetos academicamente treinados esteja aumentando, a maioria do grupo atual de gerentes de projetos não tem treinamento de campo ao longo de sua graduação, sendo provenientes em sua grande parte de escolas cuja ementa curricular foca, principalmente, em disciplinas de cálculo e tecnológicas, em detrimento das que abordam os temas de administração e organização da produção. Este trabalho tem como objetivo entender melhor a atual situação do perfil de competências dos alunos de graduação do curso de engenharia civil da Universidade de Brasília. Para isso foram levantadas na literatura 11 competências presentes no perfil de um gerente de projetos e posteriormente realizada uma pesquisa juntamente com alunos de graduação do 7º ao 10º período, através de questionário que avalia o grau de percepção dentre as 11 competências que possam ter sido desenvolvidas ou não durante sua formação, para assim realizar uma análise comparativa. Percebe-se a carência de mais da metade destas competências, levando ao questionamento sobre a forma em que a grade curricular está contribuindo para a formação desses futuros gerentes de projetos. Põem-se em questão a necessidade de revisão e reformulação de seu currículo, em função principalmente da necessidade de adequar ao mercado o perfil dos profissionais que estão sendo formados pela universidade.

Palavras-chave: competências, gestão de projetos, engenharia civil.

1 Introdução

As empresas têm passado por um processo de transformação, organizando-se para poder dar respostas eficazes e rápidas aos problemas, especialmente, aqueles que se referem à competição e posicionamento de mercado, e para se atingir resultados cada vez mais significativo torna-se importante o desenvolvimento de competências no âmbito do indivíduo e da organização (Carvalho & Rabechini, 2011).

A condução e o gerenciamento de projetos tornam-se, dessa forma, ferramentas que exercem grande influência nos resultados da empresa e a seleção do candidato correto para o cargo de gerente de projetos surge como uma tarefa árdua para as empresas. Falhar na escolha deste candidato abre margens para que os concorrentes avancem, uma vez que os projetos se caracterizam por serem ágeis e dinâmicos, não deixando tempo para uma segunda seleção durante a execução do projeto (Keelling, 2006).

Segundo o "Project Management Institute [PMI]" (PMI, 2014), um projeto pode ser definido como um esforço temporário, com objetivo de se criar um produto, serviço ou resultado único, sendo que consome recursos e busca atender prazos, custos e qualidade. O projeto pode também ser definido como todo empreendimento, com características diferentes de outros já elaborados, sendo dirigido por uma equipe de pessoas que aplicam técnicas, habilidades e ferramentas com a finalidade de satisfazer seus requisitos (Kerzner, 2010).

O gerenciamento de projetos pode ser definido como um conjunto de ferramentas com a finalidade de desenvolver as habilidades, conhecimentos e capacidades individuais, permitindo o controle de eventos não repetitivos, únicos e complexos em um cenário de tempo, custo e controles pré-determinados (Vargas, 2006).

Independentemente da fase em que o projeto esteja, algumas características são sempre observadas nos gerentes de projetos. Na literatura, observa-se alguns autores que estudaram os perfis de gerentes de projetos como: (Gaddis, 1959; Meredith & Mantel, 1985; Shtub, Bard, & Globerson, 1994; Kerzner, 1998).

Identificar o perfil mais adequado de um gerente de projetos passa a ser considerado como uma vantagem para as empresas se destacarem e obterem os resultados esperados. Embora seja essencial aos gestores conhecerem as ferramentas administrativas, o sucesso na condução de um projeto depende de características mais complexas e de difícil percepção humana, dificultando assim a seleção correta (Banzi Junior, 2011).

Embora a porcentagem de gerentes de projetos academicamente treinados esteja aumentando, a maioria do grupo atual de gerentes de projetos não tem treinamento de campo em nível de faculdade. Foram treinados diretamente no trabalho, ou em seminários e oficinas de gerenciamento de projeto (Meredith & Mantel Jr, 2003).

Um programa de formação superior em Engenharia deve dotar os indivíduos não só com sólidos conhecimentos em Ciências Básicas e de Engenharia, mas também com um conjunto de aptidões e atitudes que os tornem capazes de exercer ao mais alto nível a profissão de Engenheiro com uma grande longevidade na eficácia profissional. É essencial na formação do engenheiro civil, a capacidade de aplicar métodos científicos na resolução dos problemas concretos de Engenharia, procurando uma gestão equilibrada dos recursos disponíveis (Lopes, Mendes, Lourenço, & Pile, 2000).

Devido a formação deficiente dos engenheiros civis no que diz respeito a gestão de projetos, provenientes em sua grande parte de escolas cuja ementa curricular focada, além do necessário, em disciplinas de cálculo e tecnológicas, em detrimento das que abordam os temas de administração e organização da produção, um profissional da área de engenharia civil, ao chegar ao posto de engenheiro, apresenta um déficit de conhecimento para trabalhar com vários projetos que necessitaram de minuciosos cuidados para gerenciar prazos, custos e qualidade.

A falta de tradição e cultura do setor da construção civil no desenvolvimento do assunto gerenciamento/planejamento, que ao longo do tempo valorizou a figura do engenheiro “tocador de obra”, cuja postura era de resolver problemas à medida que elas fossem surgindo, além da preocupação intrínseca com os aspectos técnicos da obra, porém prestando pouca atenção aos problemas administrativos e gerenciais.

Um dos problemas enfrentados é que, ao chegar na vida profissional, o engenheiro muitas vezes se depara com um cargo de gestor de projetos, e não mais apenas o responsável pela obra, necessitando de competências que podem ainda não terem sido desenvolvidas.

Segundo Silveira (2005), competência seria a capacidade de mobilizar e articular conhecimentos, aptidões e atitudes para resolver eficazmente novos problemas de forma fundamentada e consciente.

Portanto, este trabalho tem como objetivo entender melhor a atual situação do perfil de competências dos alunos de graduação do curso de engenharia civil da Universidade de Brasília, do 7º ao 10º período, comparando-se com literatura disponível quanto aos aspectos importantes sobre as competências do gerente de projetos que influenciam fortemente o sucesso do projeto. A pergunta que este estudo pretende responder é: com a atual grade de disciplinas e atividades de extensão, o aluno do curso de engenharia civil está preparado para desempenhar, com excelência, seu papel como futuro gestor de projetos?

2 Método e Material

Foi desenvolvida a pesquisa qualitativa de uma amostragem intencional com no mínimo 30 respondentes através de um estudo exploratório em campo. Foram realizadas entrevistas individuais com alunos de graduação do curso de engenharia civil da Universidade de Brasília, do 7º ao 10º período, a partir de um questionário estruturado para investigar o grau de satisfação quanto ao desenvolvimento de competências ao longo da sua formação acadêmica. As questões tinham como opções de resposta a seguinte escala: 1 - Muito insatisfatória; 2 - Insatisfatória; 3 - Indiferente; 4 - Satisfatória; e 5 - Muito satisfatória.

Foi utilizado um questionário estruturado que permitiu a imparcialidade do entrevistador e uma análise comparativa dos resultados obtidos. As entrevistas foram realizadas de forma individual via formulário Google Docs disponibilizado através de um link. Posteriormente foi realizada a análise de conteúdo e por fim, foi feita uma comparação com a teoria e comentários sobre os resultados.

Nesta pesquisa foram listadas 11 competências encontradas na literatura como sendo essenciais aos gerentes de projetos que desejam obter sucesso em seus empreendimentos (Figura 1).

Figura 1. Competências do gerente de projetos

Fonte. Elaborado pelo autor

A liderança foi a primeira característica inserida na pesquisa. Apesar de liderar e gerenciar apresentarem características diferentes dentro do ambiente de projetos, ainda são duas funções muito confundidas. O gerente operacionaliza e administra o todo, utilizando-se do cargo definido e preocupando-se com as exigências do projeto, já o líder, muitas vezes informal, se mostra influente, opina e segue a frente mostrando o caminho (Dinsmore & Silveira Neto, 2004).

A comunicação é outro fator muito citado entre as características dos gerentes de projetos. A comunicação eficaz se faz necessária para garantir que as informações cheguem no tempo certo, às pessoas corretas e sem custos demasiados (Vargas, 2006). A comunicação aumenta o poder de persuasão, o comprometimento da equipe e facilita a troca de informações entre todos os envolvidos (Possi et al., 2006). Além disso, gerentes de projetos que exercem alto grau de comunicação, reduzem o tempo desperdiçado com longas reuniões, aumentam a confiança da equipe e garantem o alinhamento e compartilhamento das ideias (Rabechini Junior, 2005).

Fatores como cultura, religião e geoeconomia influenciam na forma de pensar dos indivíduos, assim é preciso cuidado quanto ao modo de agir e argumentar por parte dos gerentes. O gerente de projetos deve se utilizar da negociação, por exemplo, para conseguir fundos, pessoas e tempos adicionais quando se tem problemas no projeto que são causados por forças externas, como cliente e ciclos do negócio (Phillips, 2003).

A capacidade de resolver problemas está relacionada a forma como a equipe e gerente de projetos irão reagir. Se o gerente de projetos se concentrar em converter um problema em uma oportunidade ou no que se pode aprender com um erro, isso aumentará as chances de que sua equipe adote uma postura mais proativa acerca da resolução de problemas (Larson & Gray, 2016).

Para se solucionar conflitos é necessário identificar comportamentos de pessoas em grupo e saber como conduzi-los melhor, de modo a obter a harmonia, boa atitude e parceria. Para isso, é preciso que o gerente de projetos saiba utilizar outras competências, como as de saber observar e ouvir (Silva & Sasso, 2014).

O nível de conhecimento técnico também pode ser considerado como uma característica relevante para a obtenção do sucesso. Deve-se levar em conta a importância, do gerente de projetos, de se ter conhecimentos técnicos relacionadas a área que o mesmo pretende trabalhar, mas não sendo fator determinante. As competências técnicas são importantes para os gerentes de projetos, mas os mesmos não devem ser escolhidos somente por essa característica, visto que muitas pessoas são possuem conhecimento das técnicas, porém são incapazes de trabalhar em equipe (Kerzner, 2006).

Autoridade é definida como o poder oficializado, implicando uma influência sobre outras pessoas (Chiavenato, 2008). Na gestão moderna, determina-se que o gerente do projeto possui a autoridade absoluta, mas que deve outorgar toda a autoridade necessária dentro de sua equipe, permitindo assim que identifiquem a correta hierarquia do empreendimento (Kerzner, 2006).

A motivação exercida pelo gerente de projetos também foi uma das características analisadas. Kerzner (2006) afirma que o papel do gerente de projetos, além de orientar a equipe, é motivá-la, uma vez que equipes motivadas são mais eficazes, criativas e solucionadoras de problemas.

Gerentes de projeto que possuem plena noção do trabalho em equipe contribuem para avanço do projeto. Algumas empresas se classificam como uma equipe, mas apenas reconhecem o desempenho da equipe com gratificações ou participações nos lucros (Kerzner, 2006). Quatro considerações são apontadas para que os gerentes de projetos possam desenvolver o trabalho em equipe: construção de um ambiente estimulante, assegurar a liderança do grupo, possuir pessoal qualificado e criar um ambiente estável (Dinsmore, 2009).

Um gerente de projetos eficaz dificilmente entregará resultados caso não tenha visão holística. Com a finalidade de se ter uma execução do projeto tranquila, os gerentes com essa competência são capazes de compreender as necessidades, interesses e influências das partes interessadas, entende como as ações do projeto impactam outras áreas do projeto, outros projetos e o ambiente organizacional e também consegue entender e explicar as ações passadas e atitudes atuais de outros e antecipa o comportamento futuro (PMI, 2012).

O Coaching pode ser entendido como um momento privilegiado de interação e reflexão, no qual a equipe do projeto conta com a escuta e a percepção refinadas do gerente de projetos que os levará a repensar os rumos de seus projetos, almejando a melhoria do desempenho observado, bem como os seus próprios caminhos profissionais, descobrindo e escolhendo os melhores caminhos a serem trilhados para o seu próprio desenvolvimento (Soler & Soler, 2006).

Como trata-se de um trabalho que busca identificar o perfil dos futuros gerente de projetos, optou-se por avaliar o grau de contato com a temática gestão de projetos (Guia PMBOK®) até o momento no curso. O “Project Management Body of Knowledge” (PMBOK® Guide), em português conhecido como Guia PMBOK®, é um guia que abrange o universo do conhecimento da profissão de Gerenciamento de Projetos. O livro identifica e descreve o subconjunto do universo do conhecimento de Gerenciamento de Projetos reconhecido como boas práticas em muitos projetos na maior parte do tempo, havendo consenso pelos praticantes sobre seus valores e aplicabilidade. O Guia PMBOK® também estabelece uma linguagem comum para a profissão, servindo de referência básica para qualquer um que se interesse pelo Gerenciamento de Projetos.

3 Resultados e discussão

Após análise de conteúdo das respostas obtidas por meio de questionário aplicado através de formulário via Google Docs, obteve-se 32 respondentes dentro do perfil almejado para fim desta pesquisa. Determinou-se que para fins de parametrização, a predominância de respostas nas escalas 1 ou 2 caracterizará o cenário NEGATIVO (pessimista). A predominância de respostas nas escalas 4 ou 5 caracterizará o cenário POSITIVO (otimista). Já a predominância de respostas na escala 3 caracterizará um cenário NEUTRO (alerta).

Após uma análise ampla dos resultados pode-se constatar que dentre as 11 características avaliadas neste estudo, se considerarmos como SATISFATÓRIO, as competências que possuem mais de 50% das respostas nas escalas 4 e 5, elas são cinco competências (comunicação, resolução de problemas, técnica, trabalho em equipe e visão holística). Se considerarmos como INSATISFATÓRIO as competências que possuem mais de 50% das respostas nas escalas 1 e 2, elas são quatro competências (resolução de conflitos, motivação, autoridade e coaching). A competência de liderança possui 50% das respostas nas escalas 4 e 5 e 15,63% das respostas nas escalas 1 e 2, portanto não apresentam um nível abaixo do satisfatório. E para a competência de negociação prevalece a INDIFERENÇA, pois 43,75% dos respondentes atribuíram a escala 3, estando os demais respondentes distribuídos de forma igual entre um cenário pessimista (escalas 1 e 2) e um cenário otimista (escalas 4 e 5). Chama-se a atenção para coaching que obteve um grau de ausência de aproximadamente 100% (Figura 2 e 3).

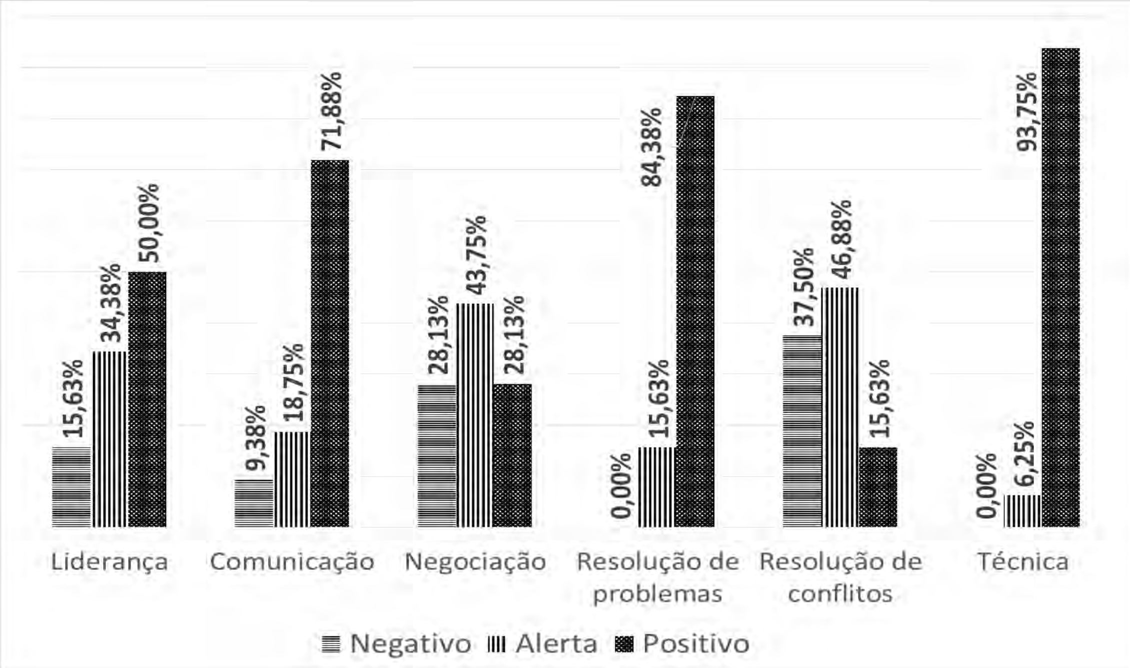

Figura 2: Resumo de cenário – Parte 1

Fonte: Resultados originais da pesquisa

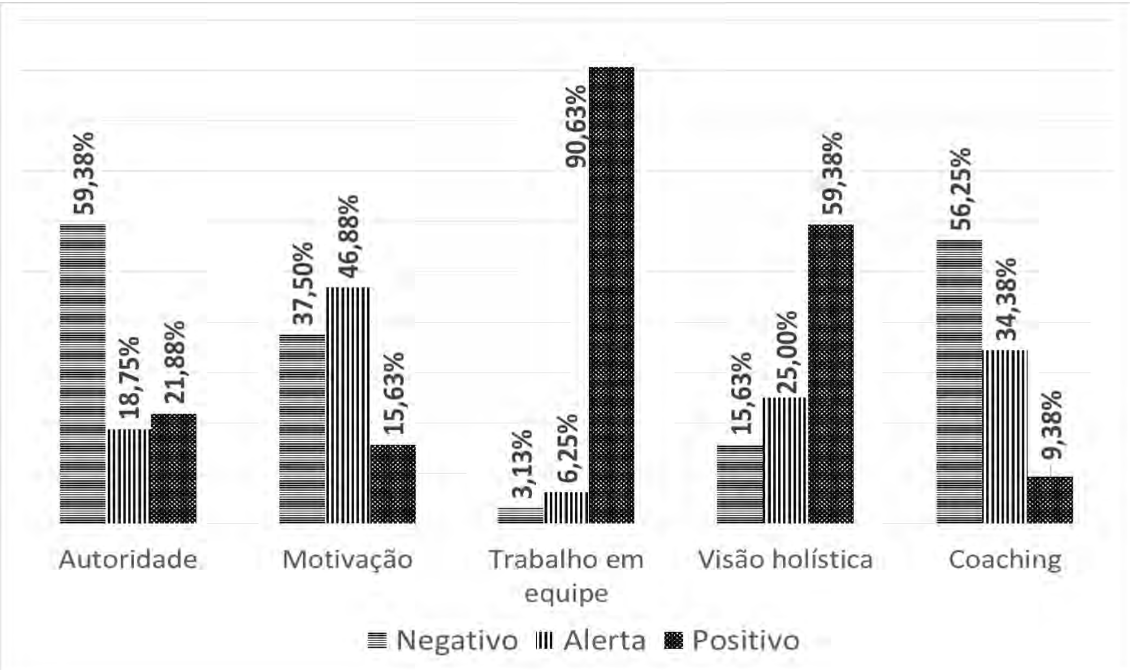

Figura 3: Resumo de cenário – Parte 2

Fonte: Resultados originais da pesquisa

Em resumo são cinco competências no cenário POSITIVO, uma competência tendendo ao cenário POSITIVO, uma competência INDIFERENTE e 4 competências no cenário NEGATIVO. Assim levantasse o questionamento sobre a forma que a grade curricular está contribuindo para a formação desses futuros gerentes de projetos.

Pode-se constatar uma grande ausência da temática Gestão de Projetos na formação acadêmica (Figura 4). Observa-se um elevado grau de insatisfação (65,63%) somada a uma tendência de indiferença (31,25%), demonstrando um cenário preocupante pessimista de 96,88%. Buscando entender esse cenário, foi constatado na grade curricular do curso somente uma disciplina denominada "Planejamento e controle de construções" que aborda o Guia PMBOK®, observação confirmada com os alunos e professora da disciplina

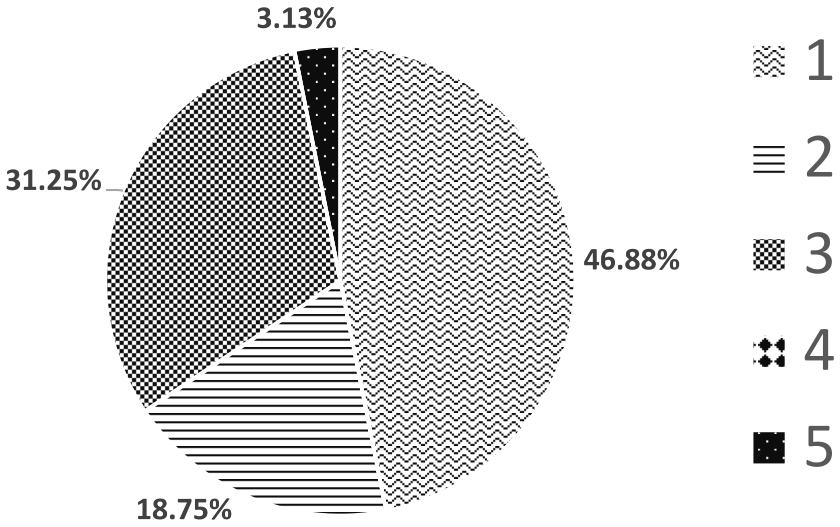

Figura 4: Contato com a temática gestão de projetos (Guia PMBOK®)

Fonte: Resultados originais da pesquisa

Põem-se em questão a necessidade de revisão e reformulação de seu currículo, em função principalmente da necessidade de adequar ao mercado o perfil dos profissionais que estão sendo formados pela universidade.

Tem-se a necessidade da utilização de uma metodologia de ensino que nos trabalhos dos alunos possa desenvolver conceitos e ferramentas gerenciais, que já são correntemente utilizadas na administração moderna. Através de projetos acadêmicos, sejam individuais ou em grupo, o aluno poderá alcançar seus objetivos e paralelamente desenvolver suas competências gerenciais e sua aptidão para gerir projetos complexos de engenharia com os instrumentos aprendidos e aplicados durante o curso.

4 Conclusão

Com essa ampla gama de perfis, esta pesquisa conseguiu identificar 11 competências presentes na literatura que se tornam apropriadas a um bom gerente de projetos. Com enfoque no curso de engenharia civil da Universidade de Brasília, conseguiu-se estabelecer o perfil dos formandos, com índices em sua maioria insatisfatórios.

Foi possível subtender falhas na grade curricular do curso sugerindo a necessidade de ser reformulada para suprir tais necessidades e ser aperfeiçoada. Pois é de suma importância que a Universidade promova para seus alunos o desenvolvimento pessoal e melhor preparação profissional para o mercado de trabalho.

A partir das observações levantadas anteriormente, como sugestão de futuros trabalhos, indica-se um estudo para implantação de novas estratégias educacionais, por exemplo Problem-Based Learning (PBL), para os alunos de graduação do curso de Engenharia Civil da Universidade de Brasília.

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Redesenho do Modelo de PBL Aplicado à Disciplina de Mecânica dos Fluidos na Engenharia com Foco em Avaliação

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Resumo

Este artigo propõe discutir comparações e mudanças na aplicação do Project Based Learning (PBL), na disciplina de Mecânica dos Fluidos, nos diversos cursos de Engenharia do Centro Universitário Salesiano de São Paulo, Brasil. Inicialmente buscou-se referências de modelos realizados em outros países como por exmplo, Olin College, MA, EUA, Universidade do Minho, pelo Prof. Dr. Rui M. Lima, Harvard University, pelo Prof. Dr Eric Mazur, a partir do qual foi estruturado o modelo Unisal Lorena. O enfoque deste trabalho tem um olhar voltado para a avaliação dos alunos pela utilização de pesos diferenciados de trabalhos individuais e em times realizados nos anos de 2015 e 2016. Isso permitiu um levantamento sobre as dificuldades e sucessos na implementação da metodologia e proposta de um novo modelo avaliativo mesclando as metodologias Team Based Learning (TBL) e Peer Instruction, aplicado em 2017. Tem-se a oportunidade de utilizar e integrar diferentes métodos de aprendizagem ativa em diversas e diferentes abordagens em grupos para a solução de problemas específicos em cada área de atuação. Assim, a proposta de fazer com que o aluno aprenda e aplique conceitos desenvolvendo projetos traz também uma forma de trabalhar competências e habilidades hoje exigidas no mercado de trabalho e que valorizam a formação global do Engenheiro. Medir o grau desse aprendizado é um desafio constante. A avaliação formativa torna-se para nós um processo a ser estudado de maneira a agregar valores ao aprendizado do estudante. Temos a necessidade de comparar e buscar um ponto de equilíbrio para estruturar e medir o grau de aproveitamento conceitual da disciplina de maneira a melhorar o engajamento dos estudantes.

Palavras chave: Project based learning, team based learning, avaliação formativa, aprendizagem, projetos

Redesenho do Modelo de PBL Aplicado à Disciplina de Mecânica dos Fluidos na Engenharia com Foco em Avalição

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Abstract

This article proposes discussing changes and comparison between PjBL applications in Fluids Mechanical Subject in any engineering courses from Centro Universitário Salesiano of São Paulo, Brazil. From the beginning got some models references in other countries as Olin College, MA, USA, Universidade do Minho, by PhD. Rui M. Lima, Harvard University, by PhD. Eric Mazur, that support to defines UNISAL Lorena model. The model´s vision was focused on student assessment with different grades for individual and team evaluations in 2015 and 2016. This was made from data by success and difficulties in methodologies implementation and proposal to a new assessment model integrating at least two methodologies: TBL – Team Based Learning and Peer Instruction, applied in 2017. The active learning methods have a big variation according each implementation and approaches for different teams as solution problems, spreadsheet or tutorials for class, individual answers systems with or without pairs instructions in class environment or flipped classroom or new environment (Freeman, Scott, 2014). As well, the new proposal to make students learning and apply concepts working with projects and prototypes get a new way to work capabilities and skills required Market for today. Measure degree for this learning is permanent challenger. The formative assessment become for us a process to be studied to measure how much student learned. We have commitment to compare and search breakeven point to structure and measure subject degree of achievement and improve student engagement.

Keywords: Active Learning; Engineering Education; Symposium Information; Project Approaches.

1 Introdução

Mudar e inovar é preciso. Adaptar-se também. O jovem milenial deste século nasceu conectado: serviços de streaming, serviços com o uso de drones, redes sociais, de negócios e corporativas, plataformas mundiais conectando e informando pessoas, marketing virtual através de lógicas matemáticas e incessantemente adentrando a mente das pessoas. Como se adaptar?

Neste contexto, o processo de aprendizagem deve compreender esta revolução tecnológica em curso e adaptar-se a ela. Fomentar o trabalho em equipe na busca por solucionar problemas, idealizar novas e inovadoras alternativas e equacionar conflitos, fazem parte da estratégia de hoje em sala de aula, onde o protagonismo do aluno possibilita exercitar esta realidade atual.

Neste sentido, os cursos superiores em engenharia pedem mudanças significativas e urgentes. De acordo com Mills (2002) os programas dos cursos de engenharia são muito focados em conteúdos (ciências e disciplinas tecnológicas) e não há integração suficiente destes tópicos com esta realidade. Dessa forma, os engenheiros recém-formados estão pouco preparados para colaborar em processos de inovação e exercer funções práticas na indústria, que são obrigadas a investir em treinamentos constantemente para a sua necessidade. Além disso, por não estar capacitado ou por não encontrar oportunidades de trabalho na indústria, 46% dos novos engenheiros acabam migrando para outras áreas de atuação (INEP, 2012).

Pode-se observar que as estratégias de ensino e aprendizagem atuais nos programas de engenharia no Brasil estão, em sua grande maioria, desatualizadas e necessitam se tornar mais centradas no estudante. Faz-se necessário incentivar o aprendizado a partir de projetos e experiências reais, aproximar a universidade da comunidade e do mercado de trabalho além de adotar currículos que estimulem habilidades transversais como gestão e criatividade.

Para Casale (2011) faltam aos alunos dos cursos de engenharia habilidades de comunicação e experiência de trabalho em equipes e os programas precisam incorporar mais oportunidades para os alunos desenvolvê-las. Os programas precisam desenvolver maior consciência entre os alunos de questões sociais, ambientais, econômicas e legais que são parte da realidade da prática moderna da engenharia.

Nesse contexto, o Project Based Learning (PBL) possibilita toda esta abordagem e contribui de maneira única para que o aluno possa exercitar a experiência de viver conflitos, cumprimento de prazos, prototipar experimentos, entregar um projeto que funcione, que atinja os objetivos propostos.

Este artigo vem apresentar a aplicação da metodologia ativa "Aprendizagem Baseada em Projetos" (PBL – *Project Based Learning*) e "Aprendizado Baseado em Times (TBL – Team Based Learning) " na disciplina Mecânica dos Fluidos dos cursos de engenharia do Centro Universitário Salesiano – UNISAL unidade Lorena.

A estratégia do curso foi estabelecida à partir da divisão do modulo em conceitos a serem estudados e desenvolvidos, três projetos a serem elaborados em grupo e apresentados como parte do processo avaliativo, trabalhos individuais e duas provas dotando-se da metodologia ativa Team Based Learning (TBL) onde o processo avaliativo se dá individualmente e em times, de maneira democrática de disseminação do conhecimento entre os alunos e permite ao professor analisar e comparar esse desenvolvimento individualmente e em times.

Esta proposta complementa o projeto inicial realizado em 2016, quando houve a implementação do PBL e, com a adição do processo avaliativo individual com o TBL, teremos uma avaliação formativa mais completa para o cotidiano atual (BARROS, 2015). Será possível ter as duas abordagens de desenvolvimento do aluno, o que para a realidade do Brasil é muito pertinente no contexto atual.

2 AS METODOLOGIAS ATIVAS

2.1 PjBL – PROJECT BASED LEARNING

A Aprendizagem Baseada em projetos (*Project Based Learning* - PBL) representa uma estratégia ou metodologia de ensino na qual os alunos trabalham com o objetivo de criar um projeto. É uma metodologia centrada no aluno, que deixa de ser o receptor passivo do conhecimento e passa a ser o agente principal responsável por seu aprendizado. A atuação do professor não segue as linhas do ensino instrucional, já que sua função é a de facilitador na construção do conhecimento e não de centralizador do saber (GIL, 2008).

No método PBL o ponto de partida para a aprendizagem é um projeto, que faz referência a uma situação que os alunos poderão enfrentar como futuros profissionais no mercado de trabalho. Instigar os alunos a construírem o próprio conhecimento não é tarefa fácil. Ela exige do professor a elaboração de estratégias para a apresentação dos projetos que serão o ponto de partida do aprendizado. O aluno também passa por mudanças profundas em sua postura, pois se vê diante da ruptura de um paradigma que vigora desde os seus primeiros anos na escola. Agora ele é o agente ativo da construção do conhecimento e não mais o receptor.

Na Aprendizagem Baseada em Projetos, o aluno passa a enxergar os conteúdos do aprendizado com os próprios olhos e não através dos olhos de outra pessoa, o que confere, assim, um significado pessoal ao conteúdo do aprendizado. Embora o significado seja atribuído pelo aluno segundo sua percepção, o professor desempenha o papel de mediador e se certifica que o significado atribuído pelo aluno seja o aceito formalmente (SOUZA, 2016).

2.2 TBL – TEAM BASED LEARNING

A Aprendizagem Baseada em Times (Team *Based Learning* - TBL) representa uma estratégia de avaliação de ensino no qual os alunos são avaliados individualmente e, em seguida, têm a oportunidade de compartilhar seus conhecimentos e democratizá-lo entre eles, em linguagem própria e maneira estruturada e direcionada pelo professor através da necessidade de responder uma avaliação em conjunto. A proposta é conhecer o quanto cada aluno aprendeu e em seguida quanto o time aprendeu e corrigiu seus erros e dificuldades. A avaliação individual e em grupos proporciona um momento de debate e convencimento entre os participantes do grupo que permite estabelecer uma relação entre o indivíduo e o grupo e se houve alguma evolução avaliativa e de aprendizado. A atuação do professor como direcionador do conhecimento a ser discutido reflete sua função de tutor e facilitador do aprendizado, sem deixar o controle de lado (GIL, 2008).

Introduzir o processo avaliativo TBL em um projeto elaborado pelos alunos em grupo onde o método PjBL foi utilizado, complementa uma abordagem de prototipar uma ideia, materializar um experimento, traduzir o conceito teórico em prático e permitir avaliá-los em grupo e individualmente.

Assim, o ciclo de aprendizagem se consolida, pois o aluno torna-se o protagonista do seu processo de aprendizagem e o professor estabelece parâmetros de avaliação individual e em times de maneira que permita avaliar a evolução do processo de aprendizagem com os projetos, desempenhando o papel de mediador conforme menciona SOUZA (2016).

2.3 A DISCIPLINA MECÂNICA DOS FLUIDOS

A disciplina de mecânica dos fluidos tem uma importância muito distinta nos cursos de engenharia. Ela não é estudada apenas por mero interesse acadêmico, ao contrário, é um assunto de larga importância nas experiências do cotidiano bem como na moderna tecnologia.

No UNISAL-Lorena a disciplina mecânica dos fluidos é ministrada no 4°semestre dos cursos de engenharia, com carga horária de 40h, e faz parte do rol de disciplinas do núcleo de conhecimento básico. A disciplina foi ministrada em 4 turmas por 3 professores distintos, em concordância de ações. Como pré-requisito para o estudo da mecânica dos fluidos, é necessário que o aluno tenha domínio do cálculo diferencial e integral e da física, além da estática e da resistência dos materiais. Ela estuda o comportamento dos fluidos em repouso (estática dos fluidos) e em movimento (dinâmica dos fluidos). O conhecimento e a compreensão dos princípios básicos da mecânica dos fluidos são essenciais para a análise de qualquer sistema no qual um fluido é o meio operante. Exemplos de áreas técnicas que exigem o conhecimento da mecânica dos fluidos por parte dos engenheiros não faltam: Projetos de aeronaves, veículos de passeio e de competição, sistemas de propulsão para voos espaciais, projetos de grandes edifícios e estruturas e os campos de escoamentos ao redor deles, chaminés, projetos de todos tipos de máquinas de fluxo como bombas, turbinas, compressores e ventiladores, sistemas de lubrificação, aquecimento e resfriamento entre tantos outros.

A luz do exposto, pode-se perceber que se trata de uma disciplina suporte nos cursos de engenharia. A partir dos conceitos estudados e ampliados pelo curso de mecânica de fluidos, o aluno poderá avançar nos seus estudos mais profundos em disciplinas de conhecimentos profissionalizantes e de formação específica como máquinas de fluxo, sistemas fluido-térmicos mecânicos, fenômenos de transporte, transferência de calor e massa, máquinas térmicas entre outras.

3 O MÉTODO DE TRABALHO

As metodologias de ensino implementadas na disciplina foram estudadas a partir do modelo do professor Jonathan Stolk, aplicado no Olin College (STOLK,2014). Toda a ementa do curso foi dividida em 3 grandes projetos a desenvolver, como mostra a tabela 1.

TABELA 1 – Desenvolvimento da Ementa do Curso em 3 Projetos

TÓPICOS (CONCEITOS)	PROJETO
Introdução à disciplina. Definição de fluido.	1
Campo de velocidade e campo de tensão	1
Tensão de cisalhamento, viscosidade e pressão	1
Tensão superficial e capilaridade	1
Fluidos Newtoneanos e não-newtoneanos	1

Propriedades dos fluidos: massa específica, volume específico, peso específico, densidade relativa.	**1**
Lei dos gases perfeitos	**2**
Estática dos Fluidos	**1**
Variação de pressão em um fluido em repouso. Princípio de Pascal. Fluidos incompressíveis. Manômetros. Lei de Stevin.	**1**
Força hidrostática sobre superfície submersa (comportas)	**2**
Princípio de Arquimedes. Empuxo e estabilidade. Densímetros.	**2**
Vazão e velocidade. Continuidade.	**3**
Dinâmica dos fluidos. Equação de Bernoulli.	**3**
Cinemática dos fluidos. Regime permanente e regime transiente	**3**
Escoamento Laminar e Turbulento. Numero de Reynolds.	**3**

Fonte: dos autores

Cada um dos três projetos deveria ter no máximo 2 meses de execução, desde a concepção da ideia até a confecção do protótipo e apresentação, contemplando assim o semestre letivo. Inicialmente, toda a turma foi dividida em grupos de no máximo 6 integrantes. Cada grupo deveria funcionar como uma empresa, elegendo um líder e gerindo seu projeto tanto no quesito técnico quanto no administrativo. Foi proposta a utilização da planilha gestão de projetos 5W2H (OLIVEIRA, 2015) a fim de registrar de maneira organizada e planejada as ações por quem, quando, onde, por que, como e quanto irá custar.
Em um primeiro momento, foi sugerida uma profunda pesquisa e revisão da literatura disponível sobre o conceito chave do projeto. Os conceitos deveriam ser discutidos e debatidos em grupo de maneira a garantir um completo entendimento por todas as partes envolvidas. A critério de cada grupo poderiam ser realizados seminários, onde cada membro se encarregaria de uma parte do conceito estudado.
Após a discussão e tempestade de ideias, os grupos deveriam projetar um dispositivo experimental de maneira a quantificar o fenômeno estudado. Todo o aparato deveria ser construído de forma simples, com materiais recicláveis do dia-a-dia, garantindo o baixo custo. Conclusivamente, os alunos deveriam idealizar meios de medição das grandezas relacionadas aos conceitos em questão, exprimindo-as através de suas leis matemáticas, demonstrando através dos dados coletados a aderência aos conceitos. Por fim, os grupos deveriam elaborar um relatório técnico utilizando-se das normas do guia de elaboração de trabalhos acadêmicos da instituição.
Em todas as etapas dos projetos as equipes se reuniam em um espaço de criação, projeto e design, denominado laboratório das engenharias do UNISAL-Lorena. Trata-se de um laboratório integrado, onde os alunos estão focados em criar e desenvolver habilidades.
Paralelamente às atividades em laboratório, os alunos fizeram uso de um ambiente virtual de aprendizado AVA – institucional, no qual poderiam acessar informações complementares sobre os temas estudados, como vídeos, artigos e experimentos, além de receber um feedback imediato pelo professor do andamento de seus projetos. A cada semana, o professor alimentava o ambiente virtual de aprendizagem AVA-institucional com pré-aulas sobre cada um dos tópicos, contendo toda a base teórica além de vídeos e artigos sobre cada tema. A cada aula, antes do início dos trabalhos em equipe, em uma mesa redonda, discutiam-se os temas estudados durante a semana, com dúvidas e questionamentos que eram respondidos e sanados pelo professor.

4 A AVALIAÇÃO

Para a metodologia de trabalho utilizada foi adotada uma forma de avaliação sistemática mista, ou seja, cada aluno foi avaliado pelo seu desenvolvimento individual com peso de 60% da nota final e 40% pelo seu trabalho em equipe.
A avaliação do trabalho em equipe se deu pela apresentação do protótipo de cada projeto proposto. Critérios como qualidade e esmero na construção, criatividade e relevância do projeto foram fatores importantes para se atribuir um conceito. Além disso, outros parâmetros como comunicação, postura, respeito aos prazos,

participação dos membros também foram fatores que contribuíram para a atribuição de uma nota. No decorrer de cada projeto também foram realizadas avaliações parciais, de modo a garantir ao aluno um retorno em curto prazo sobre seu desempenho.
A avaliação individual ocorreu a cada aula, através da verificação de presença, da entrega no prazo de relatórios experimentais individuais no ambiente virtual de aprendizagens e do engajamento do aluno com os trabalhos. Também foram executadas duas provas no modelo TBL – Team Based Learning onde o processo avaliativo se dá mediante uma avaliação individual e em equipe, através de respostas a questões testes previamente estabelecidas para este método.
Ao final de cada projeto foi utilizado um questionário de autoavaliação respondido pelo grupo, cuja intenção foi a de verificar a opinião dos alunos a respeito do método de ensino utilizado.

5 RESULTADOS

Observou-se uma maior participação dos alunos na disciplina, através do aumento de presença em sala de aula comparativamente a aulas ministradas na mesma disciplina com o uso da metodologia de ensino tradicional. Notou-se também um maior engajamento, despertando a curiosidade do aluno na busca por conceitos e formas de sua aplicação, trazendo questionamentos relevantes para a sala de aula.
Além disso, ao compararem entre si os projetos apresentados, os alunos se sentiram desafiados e motivados a aprimorar seus trabalhos, aumentando significativamente a qualidade dos protótipos e os relatórios apresentados.
Pode-se perceber um aumento do senso de responsabilidade dos estudantes, que estudavam por conta própria, com disciplina e regularidade. E das dificuldades enfrentadas, destaca-se o esforço no sentido de quebrar paradigmas do aluno enfrentar um novo método de aprendizado, que se diferencia de tudo a que ele foi acostumado em toda sua vida acadêmica.
Dessa forma, pode-se concluir que a aplicação do método PBL é uma estratégia pedagógica de ensino inovadora, trazendo para a sala de aula a interdisciplinaridade, de tal forma que o aluno deixa de ser o receptor passivo das informações transmitidas pelo professor e passa a ser o elemento principal responsável pelo seu aprendizado.

Conclui-se ainda que o acesso precoce dos estudantes ao meio prático da engenharia formará novos profissionais mais motivados e mais humanizados, já que os estudantes podem ver de perto o resultado prático de suas investigações.

6 LIMITES DO ESTUDO

Este estudo é qualitativo e demonstra a estratégia adotada para contemplar a avaliação formativa do aluno a partir da aplicação das metodologias ativas de ensino. A análise qualitativa se dará após o fechamento do ano letivo e com a possibilidade de comparação dos resultados de três anos deste projeto.

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Project-Based Learning applied in a course of a graduation program in Educational Projects

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Abstract

The Engineering School of Lorena (EEL) has a graduation program designed to natural and biological science teachers of Elementary, Middle, and High Schools. One of the courses of the program is called Educational Projects. In the first half of 2017, this course introduced the use of Project-Based Learning to a class composed by 20 students, divided into six teams of 3 or 4. The six teams carried out the following: *i*) during the first month students developed interdisciplinary projects to be applied in basic schools, *ii*) from the second to the fourth months, they applied the project, and *iii*) at the end of the fourth month, the teams gave talks on the executed projects, which were evaluated by four professors. Each group also had to submit a text on the project with the format of an academic article, which was reviewed by the professors responsible for the course, as well as other professor who contributed voluntarily. The approval on the course was conditioned to the submission of the academic article to a scientific journal of the teaching/education area. The articles described the experience of each team on the application of Project-Based Learning in a practical way. This paper reports the analysis of the results obtained with the experience and makes suggestions on what should be improved for the next semesters.

Keywords: Project-Based Learning; Active Learning; Educational Projects.

Aprendizagem baseada em Projetos aplicada em uma disciplina de um Programa de Pós-graduação em Projetos Educacionais

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Resumo

A Escola de Engenharia de Lorena (EEL) possui um programa de mestrado profissional destinado a professores de ciências exatas e biológicas do Ensino Fundamental e Médio. Uma das disciplinas deste mestrado denomina-se projetos educacionais. No primeiro semestre de 2017, essa disciplina introduziu o uso da Aprendizagem Baseada em Projetos a uma turma composta por 20 alunos, divididos em seis equipes com 3 ou 4 alunos. Durante o semestre, as seis equipes passaram pelas seguintes etapas: *i*) no primeiro mês, após uma introdução sobre Aprendizagem Baseada em Projetos, tiveram que elaborar um projeto interdisciplinar para ser aplicado numa escola de educação básica; *ii*) do segundo ao quarto mês aplicaram o projeto; e *iii*) no final do quarto mês, fizeram uma apresentação oral sobre o projeto conduzido para a avaliação de uma banca composta por quatro professores. Eles também entregaram um texto sobre o projeto realizado no formato de um artigo acadêmico, que passou por revisão dos professores que ministraram a disciplina, bem como de outros professores que contribuíram voluntariamente. A aprovação final na disciplina estava condicionada à submissão do artigo acadêmico a uma revista científica da área de ensino/educação. Os artigos descreveram a experiência de cada equipe na aplicação de Aprendizagem Baseada em Projetos de uma forma prática. Este trabalho apresenta uma análise dos resultados obtidos com a experiência e faz sugestões sobre o que deve ser aprimorado para os próximos semestres.

Keywords: Aprendizagem baseada em projetos, Aprendizagem ativa, Projetos Educacionais

1 Introdução

A educação formal vive um impasse em função de tantas mudanças na sociedade e na tecnologia: O que fazer para tornar o aprendizado mais efetivo? Problemas na educação formal vem se multiplicando nos últimos anos, tendo em vista a aceleração do processo de mudança de uma forma geral, o que potencializa, inclusive, conflitos geracionais, devido a diferentes visões entre a forma de ensinar de professores e a forma como desejam aprender os alunos. Entretanto, a responsabilidade do professor é propiciar a aprendizagem dos alunos. Conforme propõe Furlani (2001), ensinar não é só mostrar, explicar e argumentar os conteúdos, vai além disso. Ensinar está relacionado com envolver o aluno no seu processo de aprendizagem, com administrar o processo completo de ensino e aprendizagem.

Libâneo (2011) menciona que instituições de ensino atentas às demandas e necessidades da aprendizagem nesse mundo em mudança precisam repensar seus objetivos e práticas de ensino, de modo a prover a seus alunos os meios cognitivos e instrumentais de compreender e lidar com os desafios postos por essa realidade.

Segundo Moran (2015), a escola padronizada, que ensina e avalia todos de forma igual e cobra resultados previsíveis, ignora que a sociedade do conhecimento é baseada em competências cognitivas, pessoais e sociais, que não se adquirem da forma convencional e que exigem o desenvolvimento de competências socioemocionais, tais como proatividade, colaboração e visão empreendedora, dentre outras.

Métodos tradicionais de ensino, que privilegiam a transmissão de conhecimento por parte dos professores, faziam sentido quando o acesso à informação era difícil. Nos dias atuais, em que o conhecimento está ao alcance de um clique em um *smartphone* nas mãos de quase todos os alunos, é possível aprender em qualquer lugar, a qualquer hora e com muitas pessoas diferentes (Almeida; Valente, 2012).

O resultado deste ensino ainda fortemente ancorado em métodos tradicionais e com baixíssimo foco no real aprendizado dos alunos é que o Brasil tem uma péssima avaliação quando comparado com os principais países do mundo em termos de Educação.

O Brasil ocupa a 61ª colocação dentre as 63 nações mapeadas pelo Índice de Competitividade Mundial 2017 (*World Competitiveness Yearbook* – WCY), divulgado pelo *International Institute for Management Development* (IMD), com sede na Suíça. Um dos fatores relevantes analisados para a composição final deste índice é a Educação, e o Brasil ocupa a 55ª colocação dentre as 63 nações mapeadas (FDC, 2017).

O Brasil está entre os oito piores países no ranking do PISA de aprendizado de jovens na área de ciências. O país ficou na 63ª posição entre as 70 nações avaliadas nessa disciplina em 2015. O PISA é uma prova feita em países membros da Organização para a Cooperação e Desenvolvimento Econômico (OCDE) e nações convidadas, entre elas o Brasil. Nessa prova de 2015, participaram 23.141 estudantes, de 841 escolas das 27 unidades federativas do Brasil. Também nessa prova foram avaliados os aprendizados em português e matemática, tendo o Brasil ficado com a 59ª e a 65ª posição, respectivamente, entre as 70 nações avaliadas (Santos; Ribeiro, 2017)

Visando contribuir para a melhoria dos processos de ensino e aprendizagem no Brasil, a Escola de Engenharia de Lorena da Universidade de São Paulo (EEL-USP) possui um programa de mestrado profissional destinado a professores de ciências exatas e biológicas do Ensino Fundamental e Médio. Uma das disciplinas deste mestrado denomina-se projetos educacionais. No 1º semestre de 2017, essa disciplina introduziu o uso da Aprendizagem Baseada em Projetos. Os alunos da turma, professores de Educação Básica, foram divididos em equipes com a responsabilidade de aplicar um projeto em um contexto real em uma escola do Ensino Fundamental ou Médio.

Este artigo apresenta uma análise dos resultados obtidos com a experiência e faz sugestões sobre o que deve ser aprimorado para os próximos semestres.

2 Aprendizagem Baseada em Projetos

Aprendizagem baseada em projetos (ABPj) surgiu na década de 1960 em faculdades de medicina, visando preparar de forma mais adequada, os alunos da graduação para o mercado de trabalho, a partir da vivência com problemas reais que serão encontrados no cotidiano da vida profissional (Powell; Weenk, 2003). A aplicação dessa metodologia de aprendizagem na formação escolar é ainda pouco difundida na formação de professores.

A aprendizagem baseada em projetos (*Project Based Learning* em inglês) é um método de ensino centrado no aluno e baseado em três princípios do construtivismo: (i) - A aprendizagem é específica do contexto; (ii) - os alunos se envolvem ativamente no processo de aprendizagem; e (iii) – os alunos atingem os seus objetivos através de interações sociais e de partilha de conhecimento e compreensão (Cocco, 2006).

Para Powell & Weenk (2003), a aprendizagem baseada em projetos está focada em atividades desenvolvidas pelo aluno a partir de trabalho em equipe. Eles propõem que os alunos trabalhem em um projeto e entreguem uma solução dentro de um prazo determinado. E que o produto final seja um protótipo, bem como um relatório, através do qual os alunos mostram o que aprenderam e apresentam o resultado final. Ainda segundo estes autores, nesse método, uma série de projetos exploram diferentes temas e desenvolvem níveis crescentes de competências profissionais. Desta forma, os alunos aprendem a dominar as competências especificadas no currículo (conhecimentos, habilidades e atitudes) dentro do contexto da prática profissional.

As principais características desse método são: *i*) o aluno está no centro do processo; *ii*) os projetos devem ser de situações reais; *iii*) deve ser realizado em equipe; e *iv*) consiste em um processo ativo, colaborativo, integrado e interdisciplinar (Lima *et al*, 2012; Masson *et al*, 2012).

Mills & Treagust (2003) propõem que na ABPj não existe uma única resposta correta para um projeto, pois a partir de um tema em comum, os alunos devem ter liberdade de escolha sobre o caminho a ser tomado para as suas propostas e apresentar a solução que acreditam ser mais viável para o problema apresentado. Além disso, para esses autores, a ABPj exige, por parte dos alunos, que aprendam sobre um determinado conteúdo específico para a entrega do projeto, após a identificação do problema em situações reais, variando a complexidade do projeto, o que inevitavelmente impacta no desenvolvimento dos próprios alunos.

3 Contexto do Estudo

Este estudo analisa o uso do ABPj na disciplina de Projetos Educacionais do Programa de Pós-Graduação em Projetos Educacionais de Ciências (PPGPE), um programa de mestrado profissional realizado na Escola de Engenharia de Lorena (EEL) da Universidade de São Paulo (USP).

3.1 O PPGPE

O PPGPE é um dos programas de pós-graduação *stricto-sensu* (mestrado profissional) da EEL-USP. Este mestrado possui uma metodologia inovadora em relação aos cursos de pós-graduação da área de Ensino de Ciências, pois visa proporcionar de forma diferenciada a interação entre a universidade e escolas de educação básica. Este curso tem como objetivo a melhoria dos aspectos sócioeducacionais de forma sustentável e continuada, visando à formação vocacional dos estudantes do ensino básico em diferentes áreas do saber relacionadas às ciências exatas e biológicas. O público alvo principal é composto por professores de ensino fundamental e médio, que atuam em área de ciências ou correlatas.

3.2 Projetos Educacionais

A disciplina de Projetos Educacionais é uma das disciplinas obrigatórias do PPGPE e tem como objetivo auxiliar os alunos na elaboração de um projeto educacional, bem como na divulgação deste projeto em congressos ou simpósios. Esta disciplina nos seus três primeiros anos de oferecimento (2014 a 2016) foi realizada na forma de palestras com professores convidados sobre os mais variados temas envolvendo a elaboração de projetos.

Na turma do 1º semestre de 2017, a disciplina foi oferecida com base na Aprendizagem Baseada em Projetos, onde os alunos foram divididos em equipes que ficaram responsáveis por elaborar um projeto de caráter experimental e aplicar em um contexto real em uma escola de ensino fundamental ou médio. A disciplina foi conduzida por dois docentes da EEL-USP com experiências anteriores de Aprendizagem Baseada em Projetos em cursos de Engenharia.

3.3 Equipes e Temas do Projeto

A turma que cursou a disciplina de Projetos Educacionais era constituída de 21 alunos, com aulas às quartas-feiras, no horário das 14h às 18h. Os alunos foram divididos em 6 equipes. O quadro 1 apresenta o Título do projeto desenvolvido por cada uma das equipes, bem como o perfil de graduação dos alunos que compunham cada equipe.

Quadro 1 – Equipes, Projetos e Membros de cada equipe

Equipe	Título do Projeto	Formação na Graduação dos alunos
A	Robô Escova	Matemática (1), Pedagogia (1), Física (1) e Biologia (1)
B	Compostagem Orgânica	Computação (1), Matemática (1), Pedagogia (1) e Biologia (1)
C	Reaproveitamento Consciente de Alimentos	Biologia (1), Pedagogia (1) e Matemática (1)
D	Laboratório de Ensino de Matemática	Pedagogia (1), Geografia (1), Farmácia (1) e Matemática (1)
E	Segurança dos Alimentos	Biologia (1), Matemática (1) e Educação Física (1)
F	Consciência Limpa, Escola Sustentável	Matemática (1), Biologia (1) e Filosofia (1)

3.4 Etapas do Projeto e Cronograma de Atividades

Como a disciplina foi ministrada para professores do ensino fundamental ou ensino médio, e todos já possuíam um certo conhecimento de métodos de aprendizagem, apenas na primeira aula foi feita uma exposição teórica sobre ABPj e dúvidas foram esclarecidas sobre a teoria. Nesta aula, as equipes foram montadas e tiveram uma semana para desenvolver a concepção de um projeto e trazer na semana seguinte para uma primeira apresentação oral, que seria o projeto que pretendiam realizar, onde e para qual público alvo. Nesta apresentação oral na segunda semana de aula, um feedback foi dado pelos docentes da disciplina. Os alunos tiveram mais uma semana para aprimorar a concepção do projeto e entregar um projeto escrito. Um modelo de projeto foi encaminhado apenas para servir como uma "bússola" para as equipes. Os docentes da disciplina analisaram o projeto escrito e na quarta semana de aula se reuniram com os alunos e deram um feedback sobre o projeto em si. A partir desse ponto, cada uma das equipes estava liberada para partir para a realização do projeto nas escolas. Na sexta semana de aula ocorreu uma avaliação parcial do início de cada projeto. Na oitava e na décima primeira semana de aula, cada uma das equipes realizou uma apresentação oral do status do projeto, onde apontavam dificuldades que, eventualmente, podiam estar encontrando na sua realização. A partir disso, recebiam um novo feedback dos docentes da disciplina, bem como de todos os demais alunos da turma, de como poderiam estar superando as dificuldades. Na décima terceira semana de aula os alunos entregaram o relatório final em formato de um artigo acadêmico sobre o projeto que haviam realizado nos últimos dois meses. Na 14ª semana de aula cada uma das equipes fez uma apresentação oral para uma banca composta por quatro docentes convidados, banca esta que fez arguição em cada um dos projetos. O quadro 2 resume este cronograma da disciplina, bem como as principais datas e atividades realizadas.

Quadro 2 – Cronograma a atividades

Etapas	Data	Semana	Atividade
1	15 março 2017	1	Apresentação Projeto, montagem das equipes, aula teórica sobre Aprendizagem baseada em Projetos
2	22 março 2017	2	Apresentação oral do projeto. Feedback dos professores da disciplina
3	29 março 2017	3	Entrega do Projeto Escrito
4	5 abril 2017	4	Reunião com professores da disciplina para feedback do projeto escrito
5	19 abril 2017	6	Avaliação parcial do início da execução dos projetos pelas equipes.
6	3 maio 2017	8	Apresentação oral do projeto. Feedback dos professores da disciplina
7	24 maio 2017	11	Apresentação oral do projeto. Feedback dos professores da disciplina
8	7 junho 2017	13	Entrega do relatório Final em formato de um artigo cientifico
9	14 junho 2017	14	Apresentação oral final do projeto para uma banca de quatro professores convidados

Este foi o cronograma de aulas, mas a disciplina não se encerrou nesta última aula na 14ª semana, pois os alunos deveriam submeter um artigo escrito para uma revista científica sugerida pelos docentes da disciplina até o dia 4 de agosto. Trata-se de uma revista científica que publica artigos na área de educação/ensino e que possui avaliação por pares para publicação.

O artigo escrito entregue no dia 7 de junho foi devolvido aos alunos com um primeiro feedback dos docentes da disciplina no dia 21 de junho. Cada uma das equipes teve uma semana para aperfeiçoar o seu artigo e entregar uma segunda versão que foi avaliada por um revisor *ad doc* que atua na área de ensino e educação. O revisor devolveu os artigos com recomendações no dia 25 de julho. Os alunos tiveram até o dia 4 de agosto para revisar em seus artigos novamente e fazer a submissão no site da revista. A nota final de cada uma das equipes estava condicionada a submissão do artigo à revista. Todos as equipes cumpriram todas as etapas do projeto.

3.5 Avaliação da Disciplina

A avaliação da disciplina foi feita a partir do seguinte critério: 1) Apresentação oral do projeto executado na última aula com peso de 20% e 2) Avaliação do artigo pelos docentes da disciplina e pelo revisor *ad hoc* com peso de 80%.

4 Metodologia

4.1 Método de Pesquisa

Utilizou-se como método de pesquisa o estudo de caso, que segundo Voss, Tsikriktsis & Frohlich (2002) têm sido consistentemente um dos métodos mais poderosos. Esse método de pesquisa é uma técnica de investigação qualitativa, que possui enfoque indutivo para a análise de dados e foco descritivo para a apresentação de resultados. O estudo de caso possui caráter empírico que investiga um fenômeno atual no contexto da vida real, geralmente considerando que as fronteiras entre os fenômenos e o contexto onde se insere não são claramente definidas (Yin, 2005). Dentre os benefícios principais da condução de um estudo de caso estão as possibilidades do desenvolvimento de novas teorias e o aumento da compreensão de eventos contemporâneos. A pesquisa realizada possui abordagem exploratório-descritiva, visto que busca conhecer e interpretar a realidade por meio da observação, análise e interpretação de fatos aliada ao maior entendimento sobre o tema em estudo.

O método de estudo de caso pode ser utilizado para diversos tipos de investigação de acordo com Voss, Tsikriktsis & Frohlich (2002). Entre eles, está a "extensão/refinamento de teoria" que se adequa melhor à pesquisa em questão. Os autores também explanam que os casos podem ser utilizados para estruturar melhor as teorias existentes à luz das observações recolhidas, por exemplo, investigando os limites de aplicação da teoria existente. Já que o objetivo do trabalho é se justificar como pesquisa, faz-se necessário possuir certo rigor metodológico, delimitando os métodos e técnicas para coleta de dados.

4.2 Coleta de dados

Para aplicar o estudo de caso, faz-se necessário determinar os instrumentos e métodos para a coleta dos dados. Buscam-se múltiplas fontes de evidências que permitem utilizar a técnica de triangulação, compreendida como uma interação entre essas fontes, a fim de sustentar as proposições e hipóteses, observando a convergência ou divergência destas. Este conceito não apenas constitui, para alguns, uma das formas de combinar vários métodos qualitativos entre si, mas também articular métodos qualitativos e quantitativos (Flick, 2005). Ainda para este autor, a triangulação de métodos não é uma ferramenta metodológica, ou uma estratégia de validação e sim uma estratégia de validar os resultados obtidos a partir da análise dos dados. Os principais instrumentos de coleta de dados foram: 1) relatórios escritos; 2) análise das apresentações orais; e 3) questionário fechado aplicado na última aula com 5 dimensões e 20 questões.

4.3 Análise de dados

Foi feito uma redução dos dados (*data reduction*) para que fossem incluídos na análise apenas os fatos que possuíssem ligação com o objetivo da pesquisa. Tomou-se como base para a análise a descrição detalhada do caso (implementação de ABPj). Em seguida, criou-se uma espécie de *display* demonstrativo com o conjunto de dados coletados para que fosse obtida uma visão geral dos dados visando extrair informações pertinentes a serem discutidas. Este painel permitiu identificar mais claramente os padrões e as variáveis da pesquisa.

5 Resultados e Discussão

Nessa seção estão apresentados os principais resultados obtidos.

5.1 Projetos Desenvolvidos

A equipe A desenvolveu o projeto "Uso do robô escova para a iniciação de crianças no letramento científico". Este projeto foi desenvolvido com 24 alunos de uma turma de 5º ano do Ensino Fundamental de uma escola particular de Lorena - SP. Os alunos foram divididos em 6 equipes, cada uma delas com 4 alunos. Esse projeto consistiu numa competição de robôs a fim de estimular crianças no processo de iniciação ao letramento científico, ou seja, um despertar da curiosidade pela ciência por meio de atividades instigantes e lúdicas. As competências que se esperava desenvolver com esse projeto foram: *i*) aprimorar a curiosidade e criatividade natural das crianças; *ii*) desenvolver o espírito de liderança e empreendedorismo através do trabalho em equipe; *iii*) desenvolver a coordenação motora; e *iv*) desenvolver a comunicação, afetividade, valores, confiança e autoestima entre crianças, priorizando o aprendizado de cooperação mútua. No decorrer do projeto, ocorreu uma discussão sobre conceitos de artes, matemática, ciências e física. Conceitos estes que não estão presentes no currículo do 5º ano, no entanto, os alunos demonstraram facilidade em sua compreensão, pois foram apresentados de maneira contextualizada e motivadora.

A equipe B desenvolveu o projeto "Destino do resíduo orgânico". Este projeto foi desenvolvido com 16 alunos de um projeto social de educação não formal com idade entre 12 a 15 anos na cidade de Taubaté - SP. Os alunos foram divididos em 3 equipes, com 5 ou 6 membros cada uma delas. Esse projeto visou, através da técnica de compostagem, dar destino ao resíduo orgânico gerado na instituição. As competências que se esperava desenvolver com esse projeto foram: *i*) comunicação escrita: por meio de relatório do experimento a ser entregue ao professor; *ii*) comunicação oral: apresentação dos resultados aos outros alunos por meio de uma exposição; e *iii*) criatividade e curiosidade. Buscou-se desenvolver o princípio de educação ambiental através da montagem de compostagem, devido à constatação de que a destinação final do lixo gerado pela instituição era um aterro sanitário. Este projeto ampliou nos alunos a consciência ambiental, por meio de ações educativas, contribuindo assim para o desenvolvimento de práticas sustentáveis e ecologicamente corretas.

A equipe C desenvolveu o projeto "Reaproveitamento consciente de alimentos". Este projeto foi desenvolvido com 20 alunos da Educação de jovens e adultos (EJA), em uma escola municipal de São José dos Campos - SP, com faixa etária entre 23 e 86 anos. Os alunos foram divididos em 5 grupos com 4 membros cada um. O projeto teve como objetivo a verificação de como o ensino de ciências pode contribuir para a formação da cidadania, de forma especial, no que se refere à sustentabilidade. As competências que se esperava desenvolver com esse projeto foram: *i*) identificar situações em que ocorre o descarte de alimentos que poderiam ser reaproveitados; *ii*) entender e valorizar a capacidade nutricional desses alimentos; e *iii*) promover atitudes de mudanças no cotidiano, em relação ao reaproveitamento de alimentos. Verificou-se ao final do projeto que ocorreu avanço na aprendizagem dos alunos em relação ao conceito de sustentabilidade, bem como, motivação para mudança de comportamento no exercício da cidadania.

A equipe D desenvolveu o projeto "Criação de protótipos de um laboratório de ensino de matemática". Este projeto foi desenvolvido com 35 alunos do 3° ano do Ensino Médio de uma escola estadual de Guaratinguetá - SP. Os alunos foram divididos em 7 equipes com 5 alunos em cada uma. O projeto teve como propósito a criação de protótipos de um Laboratório de Ensino de Matemática (L.E.M.) que pudesse proporcionar aos alunos o contato com a matemática de forma diversificada e contextualizada. As competências que se esperava desenvolver com esse projeto foram: *i*) valorizar o trabalho em equipe; *ii*) estabelecer relações entre seus conhecimentos e por meio disso colocar em prática a sua criatividade, e *iii*) desenvolver criatividade e curiosidade. Ao final do projeto os grupos demonstraram autonomia intelectual e apresentaram sete protótipos diferenciados para o L.E.M., a partir de sólido trabalho em equipe e do engajamento dos alunos, a fim de resolver o problema proposto.

A equipe E desenvolveu o projeto "Segurança dos alimentos". Este projeto foi desenvolvido com 32 alunos do 8º ano do Ensino Fundamental de uma escola particular em Jacareí - SP. Os alunos foram divididos em 6 equipes com 5 ou 6 alunos em cada uma. Esse projeto teve como propósito a criação de receitas de comida a partir da sobra de alimentação. As competências que se esperava desenvolver com esse projeto foram: *i*) autonomia na busca pela informação, proatividade e criatividade; *ii*) gestão da informação e trabalho em equipe; *iii*) comunicação escrita e oral; e *iv*) senso crítico. No desenvolvimento do projeto, as equipes foram visitar estabelecimentos comerciais de produção e venda de alimentos, bem como realizaram entrevistas. No final do projeto, produziram um vídeo que divulgaram na web sobre como reaproveitar sobras de alimentos na criação de novos pratos.

A equipe F desenvolveu o projeto "Coleta seletiva diferenciada". Este projeto foi desenvolvido por 25 alunos do 7º ano do Ensino Fundamental de uma escola pública municipal de Piquete - SP. Os alunos foram divididos em 5 equipes com 5 alunos em cada uma. Esse projeto teve como propósito a criação de lixeiras para a coleta do lixo da escola. As competências que se esperava desenvolver com esse projeto foram: *i*) organização e trabalho em equipe; *ii*) criatividade; *iii*) comunicação; e *iv*) cumprimento de prazos. As atividades desenvolvidas envolviam a discussão, investigação e confecção de lixeiras inorgânicas e orgânicas feitas pelas equipes. Os resultados finais foram satisfatórios, pois 90% dos alunos, ao responderem um questionário final sobre o projeto, estavam conscientes da importância da coleta seletiva e responderam corretamente às questões sobre meio ambiente e lixos inorgânicos e orgânicos.

5.2 Questionário Aplicado

Um questionário fechado (tabela 1) foi aplicado na última aula com 5 dimensões e 20 questões. Neste questionário, os alunos estavam avaliando a disciplina de Projetos Educacionais e a forma como ela foi desenvolvida ao longo do semestre. A escala usada foi de 1 a 5, onde 1 representava "discordo totalmente" e 5 representava "concordo totalmente".

Tabela 1 – Questionário Aplicado

Dimensão	ID	Questão	A	B	C	D	E	F	Média
PBL	1	A utilização de ABPj na disciplina foi um diferencial no mestrado de PPGPE.	5,00	5,00	4,67	4,25	5,00	5,00	**4,81**
	2	Entendo que conceitos de ABPj deveriam ser utilizados em mais disciplinas do PPGPE	5,00	4,75	4,33	4,75	4,33	4,67	**4,67**
	3	A utilização de metodologia ABPj tornou o aprendizado mais motivador para meus alunos	5,00	4,75	5,00	5,00	4,67	5,00	**4,90**
	4	A metodologia ABPj aprimorou o desenvolvimento das relações interpessoais dos meus alunos	5,00	4,50	4,67	5,00	5,00	5,00	**4,86**
Trabalho em Equipe	5	Todos os membros da minha equipe contribuíram muito para o sucesso do trabalho	4,50	**2,25**	5,00	4,50	5,00	5,00	**4,29**
	6	Todos os membros da minha equipe participaram de todas as reuniões	4,25	**2,00**	5,00	4,50	4,00	4,67	**4,00**
	7	O sucesso da minha equipe foi função da união de seus membros	4,50	**3,25**	5,00	4,50	5,00	5,00	**4,48**
	8	Todos os membros da minha equipe cumpriram as tarefas que lhe foram determinadas.	4,25	**1,75**	5,00	4,50	4,67	5,00	**4,10**
	9	Todos os conflitos vivenciados pela minha equipe foram superados de maneira coerente e respeitosa.	5,00	**2,25**	5,00	5,00	5,00	5,00	**4,48**
Desenvol-vimento Pessoal	10	Participar deste projeto me ajudou a desenvolver minha criatividade para a resolução de problemas	5,00	5,00	4,67	4,50	5,00	4,67	**4,81**
	11	Percebo que estou com um senso crítico maior para avaliar as diferentes propostas de trabalho	5,00	4,50	4,67	4,50	5,00	5,00	**4,76**
	12	Minha participação foi importante e relevante, atendendo as necessidades da minha equipe	4,50	5,00	4,33	5,00	4,33	5,00	**4,71**
Comuni-cação	13	A comunicação na minha equipe através de um protocolo de comunicação virtual, foi eficaz.	4,50	**3,75**	5,00	5,00	5,00	5,00	**4,67**
	14	Minha capacidade de comunicação escrita foi aprimorada nesta disciplina do PPGPE	4,50	**3,75**	4,33	5,00	3,67	4,67	**4,33**
	15	Minha capacidade de comunicação oral foi aprimorada nesta disciplina do PPGPE.	4,50	4,50	3,67	4,50	4,33	5,00	**4,43**
Gestão de Projetos	16	Os papeis a as responsabilidades foram bem definidos e todos os desenvolveram bem	4,25	**2,25**	5,00	4,75	4,67	5,00	**4,24**
	17	As reuniões realizadas foram produtivas e decisivas para a continuidade do projeto	4,50	**2,25**	5,00	4,50	5,00	5,00	**4,29**
	18	Minha equipe sempre cumpriu todos os prazos estabelecidos pelos professores	5,00	5,00	5,00	5,00	4,33	5,00	**4,90**
	19	Minha equipe soube administrar bem o tempo, cumprindo o calendário proposto.	4,75	5,00	4,67	5,00	5,00	4,67	**4,86**
	20	Os conhecimentos necessários para o desenvolvimento do projeto realizado na escola foram buscados em diferentes fontes	4,75	4,75	4,67	5,00	5,00	5,00	**4,86**

A análise dos resultados revela que a média aritmética simples de todos os 20 respondentes para as 20 questões foi superior a 4 (concordo), sendo que em alguns casos essa média quase chegou a 5 (concordo totalmente). Idêntico cenário se repete ao analisar a resposta das 20 questões de cinco das equipes (A, C, D, E e F). Destaque deve ser dado para a equipe B, na qual 9 das 20 questões tiveram média inferior a 4, indo no sentido contrário de todas as outras equipes. A dimensão trabalho em equipe do grupo B revela que eles mais discordaram do que concordaram que ocorreu um efetivo trabalho em equipe entre eles. Isso de fato ocorreu, pois ao longo do semestre, essa equipe enfrentou problemas de relacionamento entre os seus membros. Essa discordância foi muito grande nesse grupo, conforme os resultados numéricos apontam claramente. Tirando esse fato isolado, referente à equipe B, no geral, todas as cinco dimensões foram muito bem avaliadas por todas as 5 outras equipes.

5.3 Submissão do Artigo a Revista

Todas as equipes submeteram seus artigos à revista recomendada pelos docentes da disciplina. Cinco das equipes já tiveram seus artigos aprovados para publicação e uma das equipes aguarda revisão solicitada pelos pareceristas da revista para decisão final.

5.4 Lições Aprendidas

Todas as seis equipes aprenderam e desenvolveram adequadamente a ABPj. Entretanto, claras oportunidades de melhoria foram detectadas. As três principais são: *i*) sugere-se que no início do curso tenha atividades com o tema trabalho em equipe, pois ficou evidenciado em uma das equipes essa necessidade; *ii*) o artigo final produzido ficou muito bom, conforme se constatou pelo alto índice de aprovação ocorrido para publicação em uma revista da área de ensino e educação, mas uma grande contribuição para isso foram as várias revisões que ocorreram a partir da entrega do artigo na última semana de aula. Sugere-se que para o futuro, temas de metodologia científica, bem como de escrita científica, sejam trabalhados ao longo do semestre; e *iii*) os alunos entregaram um único relatório final, sobre a forma de um artigo científico. Sugere-se que ocorram entregas parciais escritas e que isso seja considerado na forma de avaliação final da disciplina.

6 Conclusões

Este artigo apresenta dados sobre a aplicação da ABPj em uma turma da disciplina de Projetos Educacionais do Programa de Pós-graduação em Projetos Educacionais de Ciências da EEL-USP. As informações relacionadas a aplicação dos projetos pelos grupos de trabalho mostram que os alunos entenderam os conceitos básicos da ABPj, bem como demonstram que os projetos foram eficientemente aplicados nas escolas de ensino básico. Isso pode ser comprovado pelos altos conceitos atribuídos a avaliação da disciplina e pelo alto índice de aceitação dos artigos submetidos a uma revista da área de ensino/educação. A metodologia ativa de ensino e aprendizagem adotada na disciplina de Projetos Educacionais cria um canal adicional importante para favorecer a inserção do uso da ABPj em escolas de educação básica.

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Project-Based Learning: USP School of Engineering of Lorena Case

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Abstract

The USP-School of Engineering of Lorena Industrial Engineering program was implemented in 2012. The Project-Based Learning (PBL) approach was introduced in 2013. During 2013 and 2014, PBL was applied to freshmen students in a project-based course, during their first semester at college, in a model similar to University of Minho (Portugal) model. From a well-succeeded two-year experience, in 2015 the Industrial Engineering program implemented three courses exclusive to the development of projects: Integrated Project in Industrial Engineering I (IPEP I, first semester), Integrated Project in Industrial Engineering II (IPEP II, fourth semester) and Integrated Project in Industrial Engineering (IPEP III, seventh semester). The objective of IPEP I is to introduce freshmen students to an interdisciplinary engineering project to be developed internally, inside the campus, where the focus is to develop soft skills. IEPE II's objective is to make the students work on specific projects proposed by small and medium industries around campus or even by the university itself, since the students are more mature in their fourth semester and have more experience to develop more robust solutions and to work with real problems. The objective of IPEP III is to propose an even greater challenge, taking students completely out of the university environment and putting them to work with challenging problems at regional small and medium industries. This article presents the Project-Based Learning model that has been used at School of Engineering of Lorena through these project courses. A detailed analysis is presented, referent to several factors involving the courses, aiming to highlight common points and divergent aspects of the courses.

Keywords: Project-Based Learning, Competences Development, Engineering Education.

Aprendizagem Baseada em Projetos: Case da Escola de Engenharia de Lorena - USP

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Abstract

O curso de Engenharia de Produção da EEL-USP foi implantado em 2012. A Aprendizagem Baseada em Projetos (ABPj) foi introduzida em 2013. Nos anos de 2013 e 2014, ABPj foi aplicada numa disciplina de Projeto para os alunos ingressantes, no primeiro semestre do curso, num modelo similar ao da Universidade do Minho (Portugal). A partir da experiência bem-sucedida destes dois anos, o curso passou a ter três disciplinas específicas de projeto a partir de 2015: Projeto Integrado de Engenharia de Produção I (PIEP I no primeiro semestre), Projeto Integrado de Engenharia de Produção II (PIEP II no quarto semestre) e Projeto Integrado de Engenharia de Produção III (PIEP III no sétimo semestre). O objetivo de PIEP I é introduzir os ingressantes num projeto de engenharia interdisciplinar que seja realizado internamente no próprio *campus* escolar, onde o principal foco está no desenvolvimento de competências transversais. O objetivo de PIEP II é colocar o aluno para trabalhar em projetos específicos propostos por empresas de pequeno e médio porte da região ou pela própria universidade, uma vez que no quarto semestre, os alunos estão mais maduros e possuem maior bagagem para desenvolverem projetos de maior robustez e irem a campo trabalhar com situações reais. O objetivo de PIEP III é propor um desafio ainda maior, levando os alunos a sair completamente do âmbito universitário e a trabalhar em problemas desafiadores em empresas de pequeno/médio porte da região. Esse artigo apresenta o modelo de Aprendizagem baseada em Projetos (ABPj) que vem sendo usado na EEL-USP por intermédio destas três disciplinas específicas de projeto. Uma análise detalhada será apresentada referente a vários fatores que envolvem as três disciplinas, visando destacar os pontos em comuns e as diferenças entre elas.

Keywords: Aprendizagem Baseada em Projetos; Desenvolvimento de Competências; Educação em Engenharia

1 Introdução

A demanda por competências transversais em graduados de engenharia, que complementem as competências técnicas obtidas a partir de uma sólida formação é cada vez mais alta por parte das empresas. Devido a essa crescente evolução do perfil esperado de um profissional que ingressará no mercado de trabalho, os métodos de ensino tradicionais utilizados em grande parte das universidades não estão em sintonia com o perfil desejado pelas empresas para jovens engenheiros no início de sua vida profissional (Prince & Felder, 2006; Jollands & Molyneaux, 2012). O desenvolvimento de competências transversais, tais como: trabalho em equipe, relacionamento interpessoal, comunicação, gestão de projetos, liderança e gestão do tempo, dentre outras, pode ser acelerado a partir de abordagens educacionais baseadas em metodologias ativas de aprendizagem (Lu, 2007; Lehmann et al, 2008). Metodologias estas que são bens vindas no processo educacional, pois evitam que alunos sejam meros expectadores de aulas teóricas, uma vez que enfatizam mais o desenvolvimento de habilidades do que a transmissão da informação (Mulongo, 2013).

Bostrom, Gupta e Hill (2008) apontam que estratégias de aprendizagem ativa e voltadas para o aluno como protagonista vem sendo cada vez mais usada. E que métodos de ensino tradicionais, nos quais o professor é o único transmissor do conhecimento, estão sendo substituídos por estas novas estratégias.

Nos tempos atuais, a maioria das grandes empresas procura contratar graduados com habilidades interdisciplinares; por isso é importante para as universidades incentivar programas interdisciplinares focados no desenvolvimento de competências (Vanstone & Oorschot, 2013). Nesse sentido, a UNESCO (2010) aponta caminhos para a formação de engenheiros, ao propor "*transformar a educação de engenharia, currículos e os métodos de ensino para enfatizar a relevância e uma abordagem de resolução de problemas para engenharia*". Este relatório destaca a importância de que os currículos de engenharia sejam baseados em atividades relevantes para os alunos, dentre as quais são ressaltadas atividades de ensino baseadas em aprendizagem baseada em projetos e aprendizagem baseada em problemas.

Para aprendizagem baseada em projetos, Van Hattum-Janssen (2010) aponta que dois são os elementos comuns: (i) o envolvimento ativo do aluno, pois ele deixa de ser um receptor passivo do conhecimento, e passa a agir como construtor ativo de seu próprio conhecimento; e (ii) a natureza real de problemas com que os alunos devem lidar, que possam contribuir para um entendimento prático da futura vida profissional.

A Aprendizagem Baseada em Projetos (ABPj) foi implantada no curso de Engenharia de Produção da Escola de Engenharia de Lorena da Universidade de São Paulo (EEL-USP), em 2013. Este trabalho apresenta o modelo com que ABPj vem sendo aplicado na EEL-USP por intermédio de três disciplinas específicas de projeto.

2 Aprendizagem Baseada em Projetos (ABPj)

A ABPj (*Project Based-Learning* na língua inglesa) é uma metodologia de aprendizagem ativa que consiste em desenvolver projetos baseados em problemas reais durante o semestre, a fim de desenvolver nos alunos os conhecimentos e as habilidades que são passados na teoria (Echavarria, 2010; Samed & Cassolo, 2013).

A ABPj em cursos de engenharia vem sendo reconhecida como uma forma eficaz de preparar os alunos para a carreira profissional (Jollands & Molyneaux, 2012; Litzinger, Lattuca & Hadgraft, 2011) e sua aplicação vem crescendo devido ao seu impacto positivo na aprendizagem e no engajamento dos alunos (Powell & Weenk, 2003; Helle, Tynjala & Olkinuora, 2006; Graaff & Kolmos, 2007; Edström & Kolmos, 2014).

A ABPj exige que os alunos sejam colocados frente a problemas reais e tangíveis, podendo ter diferentes graus de dificuldade, exige um tempo adequado para a sua execução e exige um certo conhecimento prévio da turma. Os alunos devem propor soluções para um determinado problema apresentado, e para isso devem usar os conhecimentos adquiridos em diferentes disciplinas técnicas, integrando diversos conhecimentos – já que problemas do mundo real são problemas interdisciplinares – além de buscarem novos conhecimentos a partir de diversas fontes disponíveis. (Lu, 2007; Lehmann *et al*, 2008; English & Kitsantas, 2013).

Nesta abordagem educacional, o papel do professor muda, pois ele deixa de ser o portador de todo conhecimento e passa atuar como facilitador e do processo de aprendizagem e de aquisição de conhecimento (Graaff & Kolmos, 2003; Savery, 2006; English & Kitsantas, 2013). Em suma, a ABPj coloca o aluno como ator principal do seu processo de aprendizagem e o professor como facilitador deste processo.

3 Contexto do Estudo

O curso Engenharia de Produção da EEL-USP foi implantado em 2012. Desde então, recebe 40 alunos todos os anos. A primeira turma não teve aplicação de ABPj no seu primeiro ano de curso, pois o curso havia sido concebido num modelo tradicional de ensino. A ABPj foi introduzida a partir da segunda turma, em 2013. Isso ocorreu, pois em 2012, a Coordenação do Curso visitou o *Massachusetts Institute of Technology (MIT)* nos Estados Unidos, a Universidade de Minho em Portugal e a Universidade de Brasília (UnB) no Brasil. O objetivo destas visitas foi conhecer as experiências na formação de engenheiros nestas escolas. No MIT, o aprendizado foi sobre a formação de engenheiros através de metodologias ativas de aprendizagem, tais como o CDIO (*Conceive – Design – Implement - Operate*) (CDIO, 2017). Na Universidade do Minho, foi possível conhecer uma disciplina de projeto interdisciplinar aplicada aos alunos do primeiro ano do curso de Engenharia e Gestão Industrial (Mesquita *et al*. 2009). E na UnB, o aprendizado foi sobre a aplicação de ABPj no curso de Engenharia de Produção em disciplinas específicas de projeto do quarto ao décimo semestre do curso (Lima *et al*, 2012). No final do ano de 2012, a Coordenação do Curso tomou a decisão de iniciar a aplicação de ABPj para os alunos ingressantes no ano de 2013 num formato similar ao aplicado na Universidade do Minho. Nos anos de 2013 e 2014, a ABPj foi aplicada somente aos alunos do primeiro semestre do curso, e a partir de 2015, o curso passou a ter três disciplinas específicas de projeto: Projeto Integrado de Engenharia de Produção I (primeiro semestre), Projeto Integrado de Engenharia de Produção II (quarto semestre) e Projeto Integrado de Engenharia de Produção III (sétimo semestre).

3.1 Projeto Integrado de Engenharia de Produção I (PIEP I)

O objetivo de PIEP I é introduzir os ingressantes num projeto interdisciplinar de engenharia que seja realizado internamente no próprio campus escolar. As seguintes disciplinas do primeiro semestre do curso são integradas com o projeto: Cálculo I, Química I, Química Experimental I, Leitura e Produção de Textos Acadêmicos e Introdução a Engenharia de Produção.

Os alunos trabalham em equipes que são formadas aleatoriamente na primeira aula do semestre. Os projetos tratam de temas genéricos e amplos. Em 2013, o tema do projeto foi "Sustentabilidade de um campus universitário". Em 2014, foi: "Produção de Biocombustíveis". Em 2015, foi "Produção de água potável, a partir de fontes não convencionais". Em 2016, foi "Aquecimento Global". E em 2017, foi "Produção de Energia Limpa"

Cada equipe tem um tutor, um aluno veterano do curso que já fez PIEP I e que é escolhido mediante um processo seletivo. Este aluno tutor tem como função principal motivar a equipe a buscar uma solução e superar as dificuldades que vão surgindo durante a execução do projeto. Não compete ao tutor propor soluções técnicas, mas sim sugerir caminhos e levar a equipe a um processo de reflexão, quando necessário.

Um guia do projeto é entregue a todos os alunos de PIEP I na primeira aula do semestre. Este guia apresenta aos alunos o conceito de ABPj e explicita os principais objetivos a serem buscados, ao longo do semestre. Define as responsabilidades dos alunos e dos tutores. Detalha as competências que se deseja desenvolver nos alunos durante a realização do projeto, as técnicas relacionadas com o tema do projeto em si, e as transversais, com ênfase em trabalho em equipe, desenvolvimento pessoal, comunicação e gestão de projetos.

O semestre letivo tem 15 semanas. Pontos de controle são estabelecidos para o acompanhamento formal do projeto, sendo que os principais são as entregas de três relatórios ao longo do semestre: (i) – na sexta aula, as equipes entregam o projeto de pesquisa, um documento com no máximo 5 páginas, que consiste no primeiro detalhamento básico do projeto; (ii) - na nona aula, as equipes entregam o relatório preliminar, um documento com no máximo de 15 páginas, contendo a ideia do projeto já bem elaborada; e (iii) - na décima quarta aula (penúltima aula do semestre), cada uma das equipes entrega o relatório final, com no máximo 40 páginas.

Os alunos têm aulas presenciais todas as semanas. São aulas com temas relacionados ao projeto (viabilidade técnica, econômico-financeira e ambiental), ao desenvolvimento de competências transversais (palestras com psicólogos, sobre trabalho em equipe e liderança), e algumas aulas com temas gerais que lhes será útil durante toda a vida: como fazer uma boa apresentação, como fazer uma boa ata e como fazer pesquisa científica em bases de dados.

A avaliação da disciplina ocorre a partir de cinco fatores: (i) – o projeto de pesquisa; (ii) – o pré produto, ou seja, o relatório preliminar; (iii) – o processo, que consiste numa avaliação do desenvolvimento do projeto, e ocorre numa reunião conjunta entre Coordenação da disciplina e os tutores; (iv) – o protótipo, que é avaliado por dois professores convidados e que atuam na área do tema do projeto e (v) – o relatório final. A

Tabela 1 - Critérios de Avaliação

detalha como são avaliados estes fatores, bem como quem são os avaliadores. Um fator de correção, apurado a partir da aplicação de um questionário na última aula do semestre, é utilizado para a obtenção da nota individual de cada um dos alunos de cada equipe, baseado num modelo usado por Eric Mazur na Universidade de Harvard (Crouch & Mazur, 2001).

Tabela 1 - Critérios de Avaliação

FATOR DE AVALIAÇÃO	PESO	FORMA DE AVALIAÇÃO	AVALIADORES
PROJETO Projeto de Pesquisa	20%	Texto Escrito (10%) + Apresentação Oral (10%)	Professor de Leitura e Produção de Textos Acadêmicos e Professores da Equipe de Coordenação
PRÉ-PRODUTO Relatório preliminar	20%	Relatório + Apresentação Oral	Professores das Disciplinas Integradoras
PROCESSO Desenvolvimento do Projeto	20%	Reunião com todos os tutores	Tutores
PRODUTO Protótipo	20%	Apresentação do Protótipo	Professores avaliadores do Protótipo

PRODUTO Relatório Final	20%	Relatório + Apresentação Oral	Professores das Disciplinas Integradoras

Em resumo, a disciplina tem o objetivo de ser um primeiro contato dos alunos ingressantes com a metodologia de ABPj e com o ambiente geral de uma universidade, mostrando as diversas áreas do conhecimento e a importância de integrá-las para encontrar soluções para problemas reais e complexos. Os alunos se dedicam a entregar o melhor projeto possível, incluindo a demonstração de um protótipo, mas o foco principal da disciplina está no desenvolvimento de competências transversais, ou seja, está muito mais no processo de aprendizagem vivenciado pelos alunos durante o semestre do que no produto que entregam. Mas, é importante ressaltar que os alunos, ao entregar um produto tangível, sob a forma de um protótipo, passam a ter um "sentimento" sobre a vida real de um engenheiro já no primeiro semestre do seu curso de graduação.

3.2 Projeto Integrado de Engenharia de Produção II

O objetivo de PIEP II é colocar o aluno para trabalhar em projetos específicos relacionados a problemas reais propostos por empresas de pequeno e médio porte da região ou pela própria universidade. No quarto semestre os alunos estão mais maduros e possuem mais bagagem de conteúdo para desenvolverem projetos de maior robustez.

A turma de alunos é dividida em equipes. Na primeira aula do semestre, os projetos são apresentados aos alunos. Cada aluno escolhe, por ordem de preferência, quatro opções de projeto no qual gostaria de trabalhar, classificando da primeira até a quarta opção. Os alunos são alocados na sua primeira opção quando o número de alunos interessados num projeto é inferior ao número máximo de membros que cada equipe pode ter. Caso o número de alunos interessados em participar de um projeto seja maior do que o número máximo de membros que uma equipe pode ter é feito um sorteio entre os interessados. Nessa primeira rodada, cerca de 60% dos alunos ficam na sua primeira opção. Processo similar é feito numa segunda rodada para segunda opção dos alunos. Depois, numa terceira e quarta rodadas para 3ª e 4ª opção dos alunos, respectivamente. Por fim, se necessário, o professor da disciplina aloca os alunos não contemplados numa de suas quatro opções nos projetos que ainda tem vagas. Nestes dois anos, cerca de 90% dos alunos, atuaram em um dos projetos que escolheram como primeira à quarta opção.

Cada uma das equipes tem dois tutores: um da Escola, outro da empresa. Uma obrigação da empresa é indicar um responsável pelo projeto, denominado tutor na empresa. E da parte da EEL-USP, cada uma das equipes tem também um tutor. Nos projetos que envolvem temas de gestão ou de melhorias de processos o próprio professor da disciplina tem sido o tutor. Mas, nos projetos que exigem especificidade de conhecimento de alguma área da engenharia da produção, o tutor tem sido um outro professor do curso com *expertise* na área do projeto.

Os projetos são prospectados pelo professor da disciplina antes do semestre letivo começar. Ele visita as empresas e pede que elaborem um Termo de abertura do Projeto (*Project Charter*). Se necessário, na semana que antecede o início do período letivo, o professor interage com as empresas para alinhar o projeto ao nível dos alunos e ao tempo que eles terão para realizar o projeto (4 meses). A tabela 2 apresenta em linhas gerais as principais informações dos projetos desenvolvidos de 2015 a 2017.

O semestre letivo tem 15 semanas. Os alunos têm aulas presenciais em 10 das 15 semanas. Na primeira aula, o professor apresenta os projetos e as equipes de alunos são montadas. Na segunda semana de aula, todas as equipes fazem a sua primeira visita as empresas. Entre a terceira e a décima quarta semana, as equipes visitam as empresas. Em todos os projetos, o compromisso de cada equipe é de fazer pelo menos 1 visita semanal a empresa. Em alguns projetos, durante o primeiro mês, algumas equipes chegam a fazer duas visitas por semana para que possam rapidamente compreender o problema que lhes é proposto. Da terceira a sétima semana de aula, os alunos recebem noções básicas de gerenciamento de projeto. Na metade do semestre (semana 8 ou 9), as equipes fazem uma apresentação oral na empresa, com a finalidade de apresentar o que foi feito até ali no projeto, e alinhar os passos da reta final. E na última semana de aula do semestre, cada uma das equipes entrega um relatório final para o cliente e faz uma apresentação oral final do projeto.

A nota da disciplina para a equipe é obtida a partir da média ponderada de duas notas: (i) uma dada pelo professor da disciplina que avalia o produto final: o relatório e a qualidade da apresentação oral na última aula, com um peso de 80%; e (ii) uma dada pelo tutor da empresa que avalia a performance da equipe durante o semestre, bem como o relatório final, com peso de 20%. A média individual de cada um dos alunos é construída a partir de um fator de ajuste individual. Numa das duas semanas que antecede a entrega do relatório final, as equipes se reúnem, e sob orientação do professor, fazem uma avaliação da efetiva contribuição de cada um dos seus membros para o resultado final do projeto, usando a mesma ferramenta usada em PIEP-I (Crouch & Mazur, 2001). O resultado desta avaliação é usado como um fator de ajuste para a obtenção da nota individual de cada aluno.

Tabela 2 - Projetos desenvolvidos em PIEP II

Projeto	Cliente	Área(s) da Engenharia de Produção
2015-1	Cooperativa de Catadores de Lixo	Gestão Ambiental e Organização do Trabalho na Produção
2015-2	Departamento de compras EEL USP	Gestão de Processos Administrativos (Lean Office)
2015-3	Laboratório de análises clínicas	Gestão de Serviços. Gestão de Filas
2015-4	Indústria de Embalagens Alimentícias	Gestão de Processos Produtivos (Lean Manufacturing)
2015-5	Indústria de Embalagens Alimentícias	Gestão de Processos Produtivos (Lean Manufacturing)
2015-6	Departamento de Trânsito de Lorena	Logística
2015-7	Indústria de embalagens plásticas	Pesquisa Operacional
2016-1	Hamburgueria artesanal	Gestão de Processos
2016-2	Atlética estudantil	Gestão de Negócios. Gerenciamento de Projeto
2016-3	Indústria de papéis industriais	Gestão Ambiental
2016-4	Departamento de Manutenção da EEL-USP	Gestão da Manutenção. TPM
2016-5	Coordenação do Curso de Eng. Produção	Gestão de Negócios
2016-6	Coordenação do Curso de Eng. Produção	Gestão de Negócios. Gestão da Tecnologia de Informação
2016-7	Indústria de Embalagens Alimentícias	Logística
2016-8	Indústria de Embalagens Alimentícias	Gestão de Processos Produtivos (Lean Manufacturing)
2017-1	Loja Locação de Máquinas e Equipamentos	Gestão da Qualidade. Projetos Kaizen
2017-2	Loja Locação de Máquinas e Equipamentos	Gestão da Manutenção. TPM
2017-3	Indústria de papéis industriais	Gestão de Processos Produtivos (Lean Manufacturing)
2017-4	Hospital de Cooperativa Médica	Gestão Ambiental
2017-5	Hospital de Cooperativa Médica	Logística
2017-6	Indústria de Embalagens Alimentícias	Controle Estatístico da Qualidade
2017-7	Indústria de Bobinas de Aço	Gestão de Processos Produtivos (Lean Manufacturing)
2017-8	Indústria de Bobinas de Aço	Gestão de Processos Produtivos. Redução de Perdas
2017-9	Empresa de Recapagem de Pneus	Gestão de Processos Produtivos (Lean Manufacturing)

Em resumo, a disciplina visa que alunos do segundo ano do curso de engenharia tenham contato com problemas reais de empresas, a fim de que vivenciem um cenário muito próximo da realidade do mercado de trabalho. O foco desta disciplina está tanto no processo quanto no produto. No processo, porque envolve o desenvolvimento de competências transversais, uma vez que a maioria dos alunos estará vivenciando pela primeira vez um problema real numa empresa, e aprendendo, na prática, a lidar com as intempéries típicas da realização de um projeto. E no produto, pois ele tem a responsabilidade de realizar o melhor trabalho possível e entregar soluções ou propostas de soluções para os problemas que lhes foram apresentados pelas empresas. E em função disso, os alunos tem a oportunidade de ampliar o "sentimento" real da vida de um engenheiro.

3.3 Projeto Integrado de Engenharia de Produção III (PIEP III)

O objetivo de PIEP III é propor um desafio mais complexo do que o de PIEP II, levando os alunos a sair completamente do âmbito universitário e a trabalhar com problemas robustos em empresas de pequeno/médio porte da região. O processo de aprendizado dos alunos é similar ao de PIEP II. O que muda é a complexidade do projeto.

Os alunos são divididos em equipes, cuja montagem segue os mesmos procedimentos de PIEP II. A prospecção dos projetos também é similar à de PIEP II. O mais emblemático é a análise dos projetos propostos junto a empresas para que sejam mais complexos do que os PIEP II, mas num nível técnico que permita que alunos do quarto ano de engenharia possam realizar durante um semestre letivo. A tabela 3 apresenta em linhas gerais as principais informações dos projetos desenvolvidos de 2015 a 2017.

Tabela 3 - Projetos desenvolvidos em PIEP III

Projeto	Cliente	Área(s) da Engenharia de Produção
2015-1	Secretaria Municipal de Saúde	Gestão de Estoque
2015-2	Secretaria Municipal de Saúde	Gestão de Compras
2015-3	Secretaria Municipal de Saúde	Gestão da Produção. Tempo e Métodos
2015-4	Secretaria Municipal de Saúde	Gestão de Filas
2015-5	Secretaria Municipal de Saúde	Logística. Movimentação de Pacientes
2016-1	Hospital Público	Gestão de Estoque
2016-2	Hospital Público	Gestão de Compras
2016-3	Hospital Público	Gestão de Estoques - OPME
2016-4	Indústria de embalagens plásticas	Gestão de Processos Produtivos (Lean Manufacturing)
2016-5	Indústria de embalagens plásticas	Gestão de Processos Produtivos (Lean Manufacturing)
2016-6	Indústria de embalagens plásticas	Qualidade. Padronização
2017-1	Loja Locação de Máquinas e Equipamentos	Gestão de Custos
2017-2	Loja Locação de Máquinas e Equipamentos	Manutenção
2017-3	Indústria de Móveis de Aço	Lean. Gargalos
2017-4	Hospital de Cooperativa Médica	Gestão de Pessoas
2017-5	Hospital de Cooperativa Médica	Manutenção. TPM
2017-6	Hospital de Cooperativa Médica	Gestão de Custos
2017-7	Indústria de Embalagens Alimentícias	Logística
2017-8	Indústria de Bobinas de Aço	Lean
2017-9	Empresa de Recapagem de Pneus	Lean

As principais fases do projeto envolvendo os alunos são similares as de PIEP II, exceto que não há conteúdo teórico sobre gerenciamento de projetos, uma vez que os alunos já viram em PIEP II, bem como já haviam vivenciado um projeto em PIEP II.

Cada equipe tem dois tutores: um da Escola, outro da empresa, similar ao que ocorre em PIEP II. Uma diferença significativa, em alguns projetos, é que em função da especificidade técnica do projeto, o tutor por parte da escola é um profissional externo com grande experiência na área do projeto que, convidado, aceita atuar nesse papel.

As principais fases do projeto são similares as de PIEP II, exceto que os alunos já não têm mais conteúdo sobre gerenciamento de projetos e apenas prática. O semestre letivo tem 15 semanas. Os alunos têm somente 5 aulas presenciais obrigatórias, sendo a maioria para apresentação parcial do projeto e recebimento de *feedback* do professor da disciplina e de professores convidados. A avaliação da disciplina é idêntica à de PIEP II.

Em resumo, a disciplina visa que alunos do quarto ano do curso de engenharia tenham contato com problemas reais e desafiadores em empresas, a fim de que vivenciem um cenário muito próximo da realidade do mercado de trabalho. O foco desta disciplina está muito mais no produto em si, do que no processo, pois cada uma das equipes tem a responsabilidade de entregar uma solução concreta para o problema que lhe foi proposto pela empresa. Eles também desenvolvem competências transversais, mas o foco da coordenação da disciplina está no resultado que vão entregar para as empresas.

3.4 Análise e Síntese

Inicialmente é importante destacar o alto grau de reconhecimento da importância destas disciplinas de projetos sobre a ótica dos alunos. A tabela 4 mostra o resultado de questões referentes ao uso de ABPj dos alunos que cursaram PIEP I e PIEP II no ano de 2017. O questionário aplicado utilizou uma escala de 1 a 5, onde para a resposta "Discordo Totalmente" era atribuído nota 1 na escala adotada e para a resposta "Concordo Totalmente" era atribuído nota 5. Os resultados apresentados referem-se a média aritmética dos respondentes de cada turma e mostram que os alunos têm uma grande concordância que a utilização de ABPj nestas disciplinas de PIEP é um dos diferenciais do curso e que deveriam ser utilizados em outras disciplinas do curso, bem como a ABPj torna o aprendizado mais motivador e aprimora as relações interpessoais.

Tabela 4- Avaliação da utilização de ABPj nas turmas de PIEP I e PIEP II de 2017.

Questão	PIEP I	PIEP II
A utilização de ABPj na disciplina de PIEP é um dos diferenciais do curso	4,77	4,97
Entendo que conceitos de ABPj deveriam ser utilizados em mais disciplinas do curso	4,46	4,73
A utilização de metodologia ABPj torna o aprendizado mais motivador	4,47	4,85
A metodologia ABPj aprimora o desenvolvimento das relações interpessoais	4,63	4,91

As três disciplinas de projeto têm características distintas, sendo que PIEP I se diferencia muito de PIEP II, enquanto esta última é similar a PIEP III, tendo como principal diferença o grau de complexidade do projeto. A tabela 5 resume um comparativo entre as três disciplinas para vários fatores.

Tabela 5 - Comparativo entre PIEP I, PIEP II e PIEP III na EEL-USP

Fator	PIEP I	PIEP II	PIEP III
Formação das equipes	Aleatória	Alunos escolhem tema	Alunos escolhem tema
Cliente do Projeto	Interno	Interno / Externo	Externo
Tutor da EEL-USP	Aluno Veterano	Professor	Professor ou Profissional
Papel do Tutor da EEL-USP	Motivacional. Orientação	Técnico	Técnico
Tutor na Empresa	Não se aplica	Sim	Sim
Guia Projeto	Minucioso (cerca de 15 páginas)	Instruções Gerais (2 páginas)	Básico (1 página)
Contrato de Projeto	Não	Sim	Sim
Aulas Presenciais	15	10	5
Foco Maior do Projeto	Processo	Processo/Produto	Produto
Foco em Competências Transversais	Alto	Alto	Médio
Competências Técnicas	Relacionadas com disciplinas do semestre	Necessárias para o projeto	Necessárias para o projeto
Relatórios Parciais	Sim	Não	Não
Apresentações durante o projeto	5	2	2
Avaliação	40% entregas parciais 20% processo 40% entrega final	100% na entrega final (80% professor e 20% empresa)	100 % na entrega final (80% professor e 20% empresa)

Vários são os fatores que diferenciam as três disciplinas entre si. Para muitos deles, a narrativa realizada para cada uma das disciplinas já explicitou e a tabela 4 consolidou. Uma característica que todos os projetos têm em comum é que visam o desenvolvimento de competências técnicas, aquelas necessárias para realização do projeto, e de competências transversais, aquelas que preparam o aluno para a vida real do futuro engenheiro no mercado de trabalho. As competências técnicas, normalmente, estão alinhadas com o nível de conhecimento do aluno em função do semestre que ele está no seu curso. O mais importante diferencial entre as três disciplinas está no foco no desenvolvimento de competências técnicas, relacionadas com o produto do projeto em si, ou no foco no desenvolvimento de competências transversais. Em PIEP I, o foco está muito mais no desenvolvimento de competências transversais, uma vez que se trata de um aluno ingressante num curso de engenharia, com idade média de 18 anos. Em PIEP II, o professor da disciplina busca um equilíbrio entre o processo de desenvolvimento de competências técnicas e transversais. E em PIEP III, o foco está mais processo de desenvolvimento de competências técnicas do que as transversais.

4 Conclusões

O presente artigo apresentou o modelo de três disciplinas de projetos ministradas na EEL-USP e detalhou de uma forma geral como cada uma delas é realizada. E apresenta como produto final um quadro-síntese no qual é feito um comparativo entre diversos fatores relacionados com as três disciplinas. Cada uma das disciplinas, com suas particularidades, visa o crescimento dos alunos, mas cada uma delas possui características que as diferenciam entre si, sendo a mais relevante, o foco maior no desenvolvimento de competências transversais na disciplina de PIEP I (primeiro semestre) e o foco maior no desenvolvimento de competências técnicas em PIEP III (sétimo semestre).

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Project-Based Learning applied to a second-year project specific discipline of the EEL-USP Industrial Engineering Program

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Abstract

Nowadays, the demand for transversal competences in engineering graduates, which are different from those of solid technical training, is growing. These competences can be developed from educational approaches based on active methodologies. The Industrial Engineering Program of the Lorena School of Engineering of the University of São Paulo (EEL-USP) aims to develop transversal skills in its students, in addition to solid technical training. This paper describes the experience of the first 2 years of a specific project discipline in the second year of the course. In the first two years, fifteen projects were carried out, the majority being for external clients and some for internal clients of the School. A case study was done with these two classes. Data were collected through questionnaires applied to the students and non-participant observation. The final reports delivered by the teams were analysed. In view of all these sources of information, the triangulation technique was used, from different perspectives, to analyse essential questions related to project-based learning. The analysis, after these two years of implementation, allowed identifying opportunities for improvement, aiming at improving the discipline, both for students, in terms of learning, and for customers, in terms of results. The main ones were: i) to deepen the knowledge of project management tools; ii) increase the interaction among the teams during the semester; and iii) to implement the delivery of partial reports throughout the project.

Keywords: Project-Based Learning; Engineering Education; Competences

Aprendizagem baseada em projetos aplicada a uma disciplina específica de Projeto do segundo ano do curso de Engenharia de Produção da EEL-USP

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Abstract

Nos dias atuais, é crescente a demanda por competências transversais em graduados de engenharia, que sejam distintas daquelas oriundas da sólida formação técnica. Essas competências podem ser desenvolvidas a partir de abordagens educacionais baseadas em metodologias ativas. O curso de Engenharia de Produção da Escola de Engenharia de Lorena da Universidade de São Paulo (EEL-USP) tem por objetivo desenvolver competências transversais em seus alunos, além da sólida formação técnica. Este trabalho descreve a experiência dos 2 primeiros anos de realização de uma disciplina específica de projetos no segundo ano do curso. Nesses dois primeiros anos, quinze projetos foram realizados, sendo a maioria para clientes externos e alguns para clientes internos da Escola. Um estudo de caso foi feito com essas duas turmas. Dados foram coletados através de questionários aplicados aos alunos e de observação não participante. Os relatórios finais entregues pelas equipes foram analisados. Diante de todas essas fontes de informação, a técnica da triangulação foi usada, para a partir de diferentes visões, poder analisar questões essenciais relacionadas a aprendizagem baseada em projetos. A análise feita, após esses 2 anos de implantação, permitiu identificar oportunidades de melhoria, visando o aprimoramento da disciplina, tanto para os alunos, em termos de aprendizagem, quanto para os clientes, em termos de resultados. As principais foram: i) aprofundar o conhecimento de ferramentas de gestão de projetos; ii) aumentar a interação entre as equipes, ao longo do semestre; e iii) implantar a entrega de relatórios parciais ao longo do projeto.

Keywords: Aprendizagem baseada em Projetos; Ensino de Engenharia; Competências.

1 Introdução

Em pleno século XXI, em muitos cursos de engenharia, ainda se pratica o ensino do modo tradicional, como vem sendo feito a centenas de anos. Ensino esse, cujo foco está na figura do professor como ator principal do processo ensino-aprendizagem. Isso podia fazer sentido até o advento da revolução da disseminação do conhecimento nas mais diferentes plataformas que o surgimento da internet possibilitou. Atualmente, não faz mais sentido, pois o aluno tem a sua disposição o conhecimento ao alcance de sua mão com muita facilidade. Portanto, a forma de ensino-aprendizagem, vigente durante centenas de anos, baseado na ideia da transmissão de conhecimento por parte do professor carece de sentido nos dias atuais, onde cada vez mais é crescente a demanda por competências transversais em alunos de engenharia, além obviamente das competências técnicas oriundas de uma sólida formação acadêmica. Competências estas que podem ser desenvolvidas a partir de abordagens educacionais baseadas em metodologias de aprendizagem ativas.

O relatório do *World Economic Forum* (2016), intitulado "*Future of Jobs*", aponta para profundas mudanças no cenário de contratação industrial nos próximos anos, com o advento da quarta revolução industrial. Cada vez mais o desenvolvimento de competências transversais em profissionais é muito relevante, tendo em vista que muitos dos cargos, atualmente existentes, serão redesenhados. Uma única certeza parece fazer sentido: a mudança parece ser a única coisa permanente na vida de um profissional. E sendo assim, as universidades precisam se adaptar a essa realidade para estarem em sintonia com esse novo cenário da indústria 4.0.

Essa necessidade de mudança também é discutida em relatório sobre engenharia produzido pela UNESCO (2010), que aponta caminhos, tais como: "*transformar a educação de engenharia, currículos e os métodos de ensino para enfatizar a relevância e uma abordagem de resolução de problemas para engenharia*". Este mesmo relatório destaca a importância de que os currículos de engenharia sejam baseados em atividades relevantes para os alunos, dentre as quais ressalta atividades de ensino baseadas em projetos e problemas.

Visando passar do modelo de ensino-aprendizagem baseado na ideia da transmissão de conhecimento para um modelo de ensino-aprendizagem baseado no desenvolvimento de competencias técnicas e transversais, a Aprendizagem Baseada em Projetos (ABPj) foi adotada no curso de Engenharia de Produção da Escola de Engenharia de Lorena da Universidade de São Paulo (EEL-USP), a partir de 2013. Este trabalho descreve a experiência de dois anos de uma disciplina específica de projetos aplicada a alunos do segundo ano curso de Engenharia de Produção da EEL-USP.

2 Aprendizagem Baseada em Projetos

O perfil esperado de um engenheiro ao ingressar no mercado de trabalho faz com que métodos tradicionais de ensino utilizados em grande parte das universidades já não sejam mais considerados eficientes para o preparo desses jovens ao final de um curso de graduação (Jollands & Molyneaux, 2012; Prince & Felder, 2006). Escolas formadoras de profissionais vêm buscando novas formas de desenvolver competências desejadas para profissionais recém-formados, o que pode ser feito através de metodologias ativas de aprendizagem que permitem que os alunos tenham uma participação ativa nas aulas, não sendo apenas meros expectadores, pois enfatizam mais o desenvolvimento de habilidades do que a transmissão da informação e tornam o professor um agente facilitador da absorção de conhecimento (English & Kitsantas, 2013; Mulongo, 2013).

A Aprendizagem Baseada em Projetos (ABPj), do inglês *Project Based-Learning* (PjBL), é uma metodologia ativa de aprendizagem que consiste em desenvolver projetos baseados em problemas reais, a fim de desenvolver nos alunos os conhecimentos e as habilidades que são passados na teoria (Echavarria, 2010). Ela vem crescendo no ensino de engenharia devido ao seu impacto positivo na aprendizagem e engajamento dos alunos, além de ser muito útil na preparação da carreira profissional (Edström & Kolmos, 2014; Graaff & Kolmos, 2007; Helle, Tynjälä & Olkinuora, 2006), pois um dos princípios dessa metodologia é o desenvolvimento de competências, tais como: trabalho em equipe, comunicação, gestão de tempo e liderança, dentre outras (Lu, 2007).

3 Contexto do Estudo

Este estudo analisa a disciplina de Projeto Integrado de Engenharia de Produção II (PIEP-II) oferecida no quarto semestre do curso de Engenharia de Produção da EEL-USP, cujo período letivo é composto de 15 semanas. Na prática, uma turma da disciplina é aberta, anualmente, entre os meses de agosto e novembro. Esta pesquisa foi realizada com as duas primeiras turmas de PIEP-II na EEL-USP, em 2015 e 2016.

3.1. ABPj no curso de Engenharia de Produção da EEL-USP

O curso de Engenharia de Produção da EEL-USP foi implantado em 2012. Desde então, anualmente, o curso recebe 40 novos alunos. A ABPj foi introduzida a partir da segunda turma, em 2013. Isso ocorreu, pois no ano de 2012, a Coordenação do Curso visitou universidades no exterior (*Massachusetts Institute of Technology* e a Universidade de *Harvard* nos Estados Unidos, a Universidade de Minho em Portugal) e no Brasil (Universidade de Brasília). O modelo adotado na EEL-USP foi similar ao aplicado na Universidade do Minho (Lima *et al*, 2012).

Três disciplinas de projeto foram criadas. Em 2013, a disciplina de Projeto Integrado de Engenharia de Produção I (PIEP-I) no primeiro semestre. E a partir de 2015, as disciplinas de Projeto Integrado de Engenharia de Produção II (PIEP-II), no quarto semestre, e Projeto Integrado de Engenharia de Produção III (PIEP-III) no sétimo semestre). O objetivo de PIEP-I é introduzir os ingressantes de um curso de engenharia em um projeto que seja realizado dentro do campus universitário. Os projetos tratam de temas genéricos e amplos. Por exemplo, no ano de 2017, o tema do projeto foi "Produção de energia limpa". O objetivo de PIEP II é colocar o aluno para trabalhar em projetos relacionados a problemas reais que são propostos por empresas de pequeno e médio porte da região ou pela própria universidade. E em PIEP-III um desafio mais relevante e complexo do que o de PIEP-II é proposto aos alunos, fora do âmbito universitário, e em problemas robustos em empresas de pequeno/médio porte da região.

3.2. Equipes

A turma de alunos é dividida em equipes. Na primeira aula do semestre, os projetos são apresentados aos alunos. Cada aluno escolhe, por ordem de preferência, quatro opções de projeto no qual gostaria de trabalhar, ordenando da primeira até a quarta opção. Os alunos são alocados na sua primeira opção quando o número de interessados em um projeto é inferior ao número máximo de membros que cada equipe pode ter. Em seguida, realiza-se um sorteio quando o número de alunos interessados em participar de um projeto é maior do que o número máximo de membros que esse projeto pode ter. Nessa primeira rodada, cerca de 60% dos alunos conseguem ficar na sua primeira opção. Um processo similar é feito numa segunda rodada para a segunda opção dos alunos. Depois, numa terceira e quarta rodadas para 3ª e 4ª opção dos alunos, respectivamente. Por fim, se necessário, o professor da disciplina aloca os alunos não contemplados numa de suas quatro opções nos projetos que ainda tem vagas. Nestes dois anos, cerca de 90% dos alunos, atuaram em um dos projetos que escolheram de primeira à quarta opção.

3.3 Fases do Projeto, cronograma e atividades

Uma fase do projeto que não envolve os alunos é feita antes do semestre letivo começar. O professor da disciplina prospecta projetos junto às empresas e pede para cada uma delas elaborar um termo de abertura do Projeto (*Project Charter*). Se necessário, o professor interage com as empresas para alinhar o projeto ao nível dos alunos e ao tempo que eles terão para realizar o projeto (4 meses). As principais fases do projeto a qual os alunos participam estão apresentadas na tabela 1.

Tabela 1 – Fases do Projeto e Atividades

Fase	Semana(s)	Atividade
1	1	Apresentação dos Projetos e montagem das equipes.
2	2	Primeira visita ao cliente
3	3 e 4	Aula sobre Gerenciamento de Projetos; Visitas e reuniões de trabalho nas empresas
4	5 a 7	Visitas e reuniões de trabalho nas empresas
5	8 ou 9	Apresentação oral para cliente
6	10 a 14	Visitas e reuniões de trabalho nas empresas
7	15	Apresentação oral final do projeto e entrega do relatório final para cliente.

Na primeira aula, o professor apresenta os projetos e as equipes de alunos são montadas. Na segunda semana de aula, todas as equipes fazem a sua primeira visita às empresas. Entre a terceira e a décima quarta semana, as equipes visitam as empresas na periodicidade demandada pelo projeto no qual estão trabalhando. Em alguns projetos, tem sido comum algumas equipes fazerem duas visitas por semana no primeiro mês para que possam compreender rapidamente o problema que lhes é proposto trabalhar, e a partir do segundo mês, passam a fazer visitas semanais. Na terceira e quarta semana de aula os alunos recebem noções básicas de gerenciamento de projeto baseado no PMBOK. Na metade do semestre (semana 8 ou 9), na segunda turma (2016) foi feita uma apresentação oral para o cliente na sua empresa, com a finalidade de apresentar o que foi feito até aquele momento no projeto, bem como a proposta de trabalho para os dois últimos meses. Por fim, na última semana de aula do semestre, cada uma das equipes entrega um relatório final para o cliente e faz uma apresentação oral final do projeto.

Cada uma das equipes atua com um tutor para realização do projeto. Nos projetos que envolvem temas de gestão ou de melhorias de processos, o professor da disciplina tem sido o tutor. Mas naqueles que exigem especificidade de conhecimento de alguma área da engenharia da produção, o tutor tem sido algum outro professor da escola que é convidado para tal função.

3.4 Avaliação da Disciplina

Nestes dois anos, a média final da disciplina foi obtida a partir de uma avaliação feita pelo professor da disciplina (peso 80%) e de uma avaliação feita por um tutor, indicado pela empesa cliente. (peso 20%). O professor avaliou o produto final: o relatório e a qualidade da apresentação oral para o cliente na última aula. E o cliente avaliou a performance da equipe durante o semestre, bem como o produto final produzido (relatório). Por fim, a média individual de cada um dos alunos é calculada a partir de um fator de ajuste individual. Na penúltima semana de aula, as equipes são reunidas pelo professor em sala de aula, para fazer uma avaliação da efetiva contribuição de cada um dos seus integrantes para o resultado final do projeto. O resultado desta avaliação torna-se um fator de ajuste de até 10% a mais ou a menos na nota final individual de cada aluno.

4 Metodologia

4.1. Delineamento da pesquisa

O método de pesquisa utilizado foi o estudo de caso, que consiste numa técnica de investigação qualitativa com enfoque indutivo na análise de dados e enfoque descritivo na apresentação de resultados (Voss, Tsikriktsi & Frohlich, 2002). Um estudo de caso possui caráter empírico, pois investiga um fenômeno atual no contexto da vida real, geralmente considerando que as fronteiras entre os fenômenos e o contexto onde se insere não estão claramente definidas (Yin, 2005).

4.2 Coleta e Análise de Dados

A coleta de dados foi feita a partir de questionário, análise dos relatórios e de observação não participante. A coleta de dados, a partir de múltiplas fontes de evidências, permite uma triangulação seja feita, técnica esta que consiste numa interação entre diferentes fontes de dados, visando observar a convergência ou divergência entre elas. Este conceito não apenas constitui, para alguns, uma das formas de combinar vários métodos qualitativos entre si, mas também articular métodos qualitativos e quantitativos (Flick, 2005).

5 Resultados e Discussão

5.1 – Primeira Turma: 2015

Esta turma foi composta de 36 alunos divididos em 7 equipes de 5 ou 6 alunos. Os projetos desenvolvidos, bem como seus objetivos e áreas da Engenharia de Produção encontram-se no Quadro 1.

Quadro 1 - Projetos desenvolvidos – Turma 2015

Projeto	Cliente	Objetivo Projeto	Área(s) da Eng. Produção
1	Cooperativa de Catadores de Lixo	Capacitar e melhorar qualidade de vida de pessoas em situação de vulnerabilidade socioeconômica	Gestão Ambiental e Organização do Trabalho na Produção
2	Departamento de compras EEL USP	Identificar gargalos e propor melhorias para o processo de compras	Gestão de Processos Administrativos (Lean Office)
3	Laboratório de análises clínicas	Elaborar um aplicativo de agendamento dos pacientes	Gestão de Serviços. Gestão de Filas
4	Indústria de Embalagens Alimentícias	Aumentar o índice OEE (*Overall Equipment Effectiveness*) de um equipamento industrial	Gestão de Processos Produtivos (Lean Manufacturing)
5	Indústria de Embalagens Alimentícias	Reduzir o tempo do setup de duas impressoras industriais.	Gestão de Processos Produtivos (Lean Manufacturing)
6	Departamento de Trânsito de Lorena	Mapear rotas e propor placas de sinalização de trânsito	Logística
7	Indústria de embalagens plásticas	Analisar e padronizar as variáveis de um processo produtivo.	Pesquisa Operacional

A análise do quadro 1 revela que seis dos projetos foram realizados com clientes externos (projetos 1, 3, 4, 5, 6 e 7) e uma com um cliente da própria universidade (projeto 2). Quatro dos projetos foram realizados em empresas de serviços (projetos 1, 2 3 e 6) e os demais 3 projetos foram realizados em indústrias (projetos 4, 5 e 7). Em três dos projetos (1, 2 e 6), o tutor foi o professor da disciplina e, nos demais quatro projetos, os tutores foram outros professores da EEL-USP. Os principais resultados entregues em cada um dos projetos foram: Projeto 1: a melhoria do processo produtivo da Cooperativa e uma melhor organização do ambiente de trabalho; Projeto 2: O desenho do macroprocesso e dos principais sub processos, resultando em oito propostas concretas de melhorias; Projeto 3: um mapeamento dos processos de agendamento e a criação de um aplicativo visando reduzir o tempo de atendimento dos pacientes; Projeto 4: uma padronização nas operações da linha de produção a partir de normas que foram propostas e aprovadas pela empresa; Projeto 5: O mapeamento do processo e a criação de instruções de trabalho que após aprovadas foram objeto de um treinamento *in loco* com operadores; Projeto 6: o mapeamento das rotas de trânsito da cidade de Lorena, bem como a identificação de pontos estratégicos a partir de medição do fluxo de veículos; e Projeto 7: a análise, a partir de modelos matemáticos do processo com cerca de 150 variáveis e a identificação das 3 variáveis de maior impacto.

5.2 A segunda turma: 2016

Esta turma foi composta de 42 alunos divididos em 8 equipes de 5 ou 6 integrantes. Os projetos desenvolvidos, bem como seus objetivos e áreas da Engenharia de Produção encontram-se no Quadro 2.

Quadro 2 - Projetos desenvolvidos – Turma 2016

Projeto	Cliente	Objetivo Projeto	Área(s) da Eng. Produção
8	Hamburgueria artesanal	Padronizar processos de retaguarda	Gestão de Processos
9	Atlética estudantil	Organizar e realizar de forma profissional uma corrida de rua	Gestão de Negócios. Gerenciamento de Projeto
10	Indústria de papéis industriais	Analisar alternativas para gerar receita a partir dos resíduos do processo produtivo de papel laminado.	Gestão Ambiental
11	Departamento de Manutenção da EEL-USP	Analisar e propor melhorias para o gerenciamento de serviços de manutenção	Gestão da Manutenção. TPM
12	Coordenação do Curso de Engenharia de Produção	Elaborar o site na internet do curso de Engenharia de Produção.	Gestão de Negócios
13	Coordenação do Curso de Engenharia de Produção	Realizar evento científico de Engenharia de Produção	Gestão de Negócios. Gestão da Tecnologia de Informação
14	Indústria de Embalagens Alimentícias	Organizar o estoque da casa de tintas da indústria	Logística
15	Indústria de Embalagens Alimentícias	Aumentar a produtividade de uma impressora industrial	Gestão de Processos Produtivos (Lean Manufacturing)

A análise do quadro 2 revela que quatro projetos foram realizados em clientes externos (projetos 8, 10, 14 e 15) e quatro em clientes da estrutura da universidade (projetos 9, 11, 12 e 13). Cinco dos projetos foram realizados em temas mais afeitos a serviços (projetos 8. 9, 11, 12 e 13) e os demais 3 projetos foram realizados em indústrias (projetos 10, 14 e 15). O Tutor dos projetos 8, 9, 12 e 13 foi o professor da disciplina e os demais quatro projetos tiveram como tutor, professores da EEL-USP. Os principais resultados entregues em cada um dos projetos foram: Projeto 8: Um mapeamento dos processos com a padronização dos principais sub processos da retaguarda sem prejudicar o perfil artesanal da hamburgueria; Projeto 9: a realização da corrida com a presença de 300 corredores e a elaboração de um manual com 45 páginas que foi entregue para a Atlética para as próximas edições; Projeto 10: Três propostas concretas para o aproveitamento dos resíduos do processo produtivo de papel laminado; Projeto 11: uma cartilha com diversas orientações práticas para a melhoria da prestação de serviços foi elaborada e foi aprovada pelos gestores da área; Projeto 12: O site foi elaborado e passou a ser a página oficial do curso: www.producao.eel.usp.br; Projeto 13: a realização do I Simpósio Acadêmico de Engenharia de Produção (SAEPRO) com a participação de 93 professores e alunos de 8 escolas diferentes; Projeto 14: O estoque da Casa de Tintas foi organizado, e um mapa informativo com as especificações da cada posição de diferentes tintas, e seu respectivo endereçamento foi entregue; e Projeto 15: Um estudo de tempos e métodos foi realizado e através da aplicação de técnicas de redução de setup o tempo de parada de equipamentos foi reduzido.

5.3. Questionário

Um questionário com 14 questões fechadas foi aplicado na última aula do semestre de cada uma das duas turmas e foi respondido individualmente. Utilizou-se a escala Likert de 5 pontos na qual 1 representa "discordo totalmente" e 5 representa "concordo totalmente". Estas questões estavam vinculadas a 4 dimensões: (i) – Aprendizagem baseada em Projetos (ABPj); (ii) – Trabalho em equipe; (iii) – Desenvolvimento pessoal; e (iv) – Gestão de projetos. No final do questionário havia um espaço para os alunos apresentarem sugestões e/ou críticas à disciplina. A média obtida para cada uma das 14 questões encontra-se na Tabela 1. A turma de 2015 tinha 36 alunos e o questionário foi respondido por 32 alunos. A turma de 2016 tinha 42 alunos e o questionário foi respondido por 34 alunos.

Tabela 1 – Média Obtida por questão (turmas 2015 e 2016)

Dimensão	ID	Questão	2015	2016	Diferença
Aprendizagem baseada em Projetos	1	A utilização de ABPj em PIEP-II é um dos diferenciais do curso	4,97	4,85	-0,12
	2	Entendo que conceitos de ABPj deveriam ser utilizados em mais disciplinas do curso	4,50	4,68	0.18
	3	A utilização de ABPj torna o aprendizado mais motivador	4,72	4,71	-0.01
	4	A metodologia ABPj aprimora o desenvolvimento das relações interpessoais	4,94	4,79	-0.15
Trabalho em Equipe	5	Todos os membros do grupo contribuíram muito para o sucesso do trabalho	3,72	4,26	0.54
	6	O sucesso de meu grupo foi função da união entre seus membros	4,22	3,97	-0.25
	7	Todos do grupo cumpriram com as tarefas estabelecidas	4,09	4,35	0.26
	8	Todos os conflitos vivenciados pelo grupo foram superados de maneira coerente e respeitosa.	4,63	4,58	-0.05
Desenvolvimento Pessoal	9	O projeto ajudou no desenvolvimento de minha criatividade para a resolução de problemas	4,31	4,32	0.01
	10	Percebo que desenvolvi neste projeto um senso crítico maior que me ajuda a avaliar as diferentes propostas de trabalho	4,38	4,62	0.24
Gestão de Projetos	11	As reuniões ocorridas foram produtivas e decisivas para os bons resultados do projeto	4,00	4,18	0.18
	12	Meu grupo cumpriu todos os prazos estabelecidos	3,91	4,35	0.44
	13	Meu grupo soube administrar bem o tempo, cumprindo o calendário proposto.	3,47	3,94	0.47
	14	Os conhecimentos necessários para o desenvolvimento do projeto foram buscados em diferentes fontes	4,03	4,71	0.68

A média por dimensão foi apurada e encontra-se na Tabela 2.

Tabela 2 – Média obtida por dimensão (turmas 2015 e 2016)

Dimensão	2015	2016	Diferença
Aprendizagem baseada em projetos	4.78	4.76	**-0.02**
Trabalho em equipe	4.16	4.29	**0.13**
Desenvolvimento pessoal	4.34	4.47	**0.13**

Gestão de projetos	3.85	4.29	**0.44**

De forma geral, os resultados da Tabela 2 apontam para uma melhoria em três das dimensões analisadas, duas delas com uma pequena alta na média (trabalho em equipe e desenvolvimento pessoal) e uma com um aumento da média mais significativo (gestão de projetos). Em relação ao uso da metodologia de aprendizagem baseada em projetos, a média foi praticamente a mesma, sendo que os alunos revelaram um ótimo grau de satisfação.

Em relação a trabalho em equipe, a média da turma de 2016 foi um pouco maior que a da turma de 2015. Entretanto, as médias das questões 5 (3,72) em 2015 e 6 (3,97) em 2016 estão entre as menores de todo o questionário, fato esse corroborado pela afirmação de um aluno da turma de 2015:

> Faltou muita proatividade e comprometimento do grupo inteiro. Isso atrapalhou o andamento do projeto. A proposta foi muito boa, mas não estávamos preparados para sermos "largados" para esse desafio.

A crítica supracitada possui uma certa relação com os resultados das questões 12 e 13 (dimensão gestão de projetos) que apontam uma maior dificuldade com gestão do tempo e cumprimento de prazos.

De forma geral os resultados apurados no questionário, bem como comentários feitos, apontam que o caminho escolhido tem se revelado adequado até este momento, mas pode e deve ser aprimorado.

5.4 Lições aprendidas

Os principais aprendizados obtidos na primeira turma de PIEP II foram:

1 - O contrato de projeto não estava adequado ao que de fato o cliente queria em alguns dos projetos. Isso ocorreu, pois algumas das empresas/clientes estavam fazendo pela primeira vez um contrato de projeto, e em função disso, as "expectativas dos clientes" não foram plenamente atendidas.

2 – Durante o semestre, não houve nenhuma reunião de avaliação formal com o cliente para que o projeto pudesse ser objeto de análise, e se necessário, fosse realinhado.

3 – Identificou-se a necessidade de maior *feedback* para os alunos ao longo do semestre pois o único feedback formal ocorrido foi em relação ao relatório final

Na turma de 2016, estas três lições foram incorporadas. O contrato de projeto foi feito com uma antecedência maior entre o professor da disciplina e cada um dos contratantes, e em função disso, foram melhor elaborados para esta turma. Uma avaliação formal foi feita no meio do semestre, quando cada equipe teve que fazer uma apresentação oral de 15 minutos na empresa do cliente, com o professor presente. Em função disso, alguns projetos foram realinhados para a segunda metade do semestre. O terceiro ponto foi da avaliação preenchida. Na turma de 2016, uma reunião ocorreu entre todos os alunos de cada projeto na metade do semestre, na qual eles se auto avaliaram entre siem relação a efetiva contribuição de cada um para o resultado do projeto até aquele momento. Em função disso foi possível verificar que a contribuição dos alunos, de uma forma geral, ao final do projeto, foi bem mais homogênea nessa turma de 2016, fato que, provavelmente, possa ter ocorrido em função da auto avaliação realizada.

Na segunda turma (2016), novas lições puderam ser aprendidas e são apontadas como oportunidades de melhorias:

1 Sugere-se aprofundar o conhecimento de ferramentas de gestão de projetos nas primeiras aulas, pois essa foi a dimensão com a menor média em ambas as turmas. E que isso seja feito, com um foco maior em gestão do tempo, visto que nos dois anos. as menores médias apuradas pelo questionário foram neste ponto.

2 Sugere-se uma maior interação entre as equipes, pois cada uma delas tem ficado mergulhada no seu projeto. Propõem-se que sejam feitas apresentações parciais também para os colegas, momento no qual as equipes poderão trocar experiências e receber um *feedback* a partir de pontos de vista diferentes.

3 Sugere-se que durante a realização do projeto, as equipes entreguem relatórios parciais do andamento do projeto, pois assim o professor poderá ter maior controle e acompanhar mais de perto

cada um dos projetos.

6 Conclusão

A realização de um projeto, através de uma disciplina obrigatória da grade do curso, no quarto semestre, obteve bons resultados nesses 2 anos, tanto para os alunos, em termos de aprendizagem, quanto para os clientes, em termos de resultados. Mas, desafios ainda persistem, tais como: 1) aprofundar o conhecimento de ferramentas de gestão de projetos; 2) uma interação maior entre as equipes, ao longo do semestre; e 3) a entrega de relatórios parciais ao longo do projeto. Por isso, é importante que um trabalho de melhoria contínua, ano a ano, continue a ser feito, visando alcançar o nível de ensino-aprendizagem das melhores universidades do mundo.

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Evaluating direct and indirect results of the active methodology in learning: proposal of an integrative design in 360º via unified platform

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Abstract

This article aims to present the design of a Uni fi ed Platform of Active Methodology through the survey of requirements. The Platform will be developed to support the improvement of the evaluation process of the Production Systems Projects (PSP's) disciplines of the Production Engineering course at the University of Brasília (EPR / UnB) and will enable the measurement of the effectiveness of the teaching approach. Project disciplines are offered starting in the fourth semester through an active methodology (Project Based Learning - PBL) and provide the development of professional skills required by the labor market in which the production engineer is inserted, as well as working in the areas of knowledge involved in this profession. Therefore, the Platform will be a tool for integrating all the results and inputs of the projects that occur from the fourth to the tenth semester, from the reception of the problems coming from external agents, until the completion of the disciplines. The access of the users of the Platform is guaranteed, consolidating a measurement of the results in 360 degrees. The importance of designing the system, well accepted by customers, is in the efficacy of its development and subsequent implementation, providing automation of the evaluation of this methodology so relevant to the Engineer (EPR / UnB). The research is exploratory and takes into account studies already done on the subject and the opinion of specialists. As a result, the design of the platform is expected to include modules that will later be integrated and used throughout the disciplines, as well as: Request for Projects, Surveys, Cross-Sectional Evaluation, Evaluations, Disclosures and Reports, and integrate with existing systems. existing in UnB, such as web-enrollment, Moodle and users. This project was approved in the Deanship of Undergraduate Education (DEG of UnB) and will receive R $ 25,000 (twenty five thousand reais) for implementation of the reported design.

Keywords: Evaluation of active methodologies; New technologies; Requirements; Integration of results.

Avaliando resultados diretos e indiretos da metodologia ativa na aprendizagem: proposta de um desenho integrador em 360º via plataforma unificada.

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Abstract

Este artigo tem como objetivo apresentar o desenho de uma Plataforma Unificada de Metodologia Ativa por meio do levantamento de requisitos. A Plataforma será desenvolvida a fim de apoiar a melhoria do processo de avaliação das disciplinas Projetos de Sistemas de Produção (PSP's) do curso de Engenharia de Produção da Universidade de Brasília (EPR/UnB) e possibilitará a mensuração da eficácia da abordagem de ensino. As disciplinas de projetos são oferecidas a partir do quarto semestre via metodologia ativa (Aprendizagem Baseada em Projetos - PBL) e propiciam o desenvolvimento de competências pressionais exigidas pelo mercado de trabalho em que o engenheiro de produção está inserido, além de trabalhar as áreas de conhecimento envolvidas nessa profissão. Sendo assim a Plataforma será uma ferramenta de integração de todos os resultados e insumos dos projetos que ocorrem do quarto ao décimo semestre, a partir da recepção dos problemas oriundos dos agentes externos, até a conclusão das disciplinas. O acesso dos usuários da Plataforma ficam garantido, consolidando uma mensuração dos resultados em 360 graus. A importância do desenho do sistema, bem aceito pelos clientes, está na eficácia de seu desenvolvimento e posterior implementação, proporcionado a automatização da avaliação dessa metodologia tão relevante para a formação do Engenheiro (EPR/UnB). A pesquisa é do tipo exploratória e leva em consideração estudos já realizados sobre o tema e a opinião de especialistas. Espera-se como resultado que o desenho da plataforma contemple módulos que posteriormente se integrarão e serão utilizados ao longo das disciplinas, bem como: Solicitação de Projetos, Pesquisas, Avaliação Transversal, Avaliações, Divulgações e Relatórios, além de se integrarem com os sistemas já existentes na UnB, tais como matrícula-web, Moodle e usuários. Este projeto foi aprovado no Decanato de Ensino de Graduação (DEG da UnB) e receberá R$ 25.000 (vinte cinco mil reais) para implementação do desenho relatado.

Palavras-chave: Avaliação de metodologias ativas, Novas Tecnologias, Requisitos, Integração de resultados.

1 Introdução

A metodologia PBL (*Project Based Learning*), traduzido como Aprendizado Baseado em Projetos, é uma das estratégias pedagógica/didática centrada no estudante. Essa metodologia de aprendizagem está relacionada às teorias construtivistas, em que, devido a necessidade de um enfoque sistêmico e amplo, o conhecimento é tratado como algo não absoluto, ou seja, o estudante tem o poder, junto aos seus professores, de construir uma percepção global sobre vários temas (Brandão, Lessandrini, & Lima, 1998).

O currículo do curso de Engenharia de Produção da Universidade de Brasília foi estruturado com base na metodologia PBL a fim de capacitar o engenheiro a lidar com as problemáticas dentro de uma visão holística. Adota sete disciplinas de projetos, denominadas PSPs (Projetos de Sistemas de Produção) como a espinha dorsal, do quarto ao décimo semestre do curso que tem o intuito de desenvolver no aluno competências transversais, tais como liderança, gerenciamento, proatividade, além das competências técnicas adquiridas ao longo do curso (Monteiro *et al.*, 2017)

A estratégia pedagógica procura, desta forma, garantir uma visão articulada entre as características da atuação profissional e as diferentes áreas de conhecimento, permitindo compreender a diversidade de aspectos determinantes envolvidos na solução de problemas da ciência em questão. Os PSPs são estruturados em 4 ancoras principais: disciplina de metodologia de projetos sustentáveis; disciplina de conteúdo técnico; agentes externos (*stakeholders*) vinculados a problemas reais; e outras disciplinas, que contemplam outas áreas de conhecimento, com interesses em tópicos específicos do projeto.

Um dos grandes desafios dessa metodologia é a avaliação da eficiência de sua implementação ao longo do curso de Engenharia de Produção. A importância desse método de avaliação é que este irá contribuir para que o curso fornecido pela Universidade de Brasília esteja de acordo com a demanda do mercado de trabalho.

Desta forma, este artigo propõe a elaboração de uma plataforma que permitirá medir a eficácia desse processo de ensino atualmente utilizado e que forneça *feedbacks* e informações substanciais e seguras para o redirecionamento das disciplinas ao longo dos anos, para não só acompanhar as exigências do mercado, mas também para estar sempre alinhado às expectativas de todos os *stakeholders* do curso.

Este artigo está estruturado em 6 seções, ao qual na seção 2 apresenta o referencial teórico aplicado ao artigo. Na seção 3 é apresentado o método de pesquisa, na seção 4 é apresentado a metodologia aplicado a pesquisa, na seção 5 é apresentado os resultados e na seção 6 traz as conclusões.

2 Referencial Teórico

O referencial teórico apresenta os conceitos utilizados para a abordagem do desenho da Plataforma Unificada de Metodologia Ativa – PUMA.

2.1 - Project Based Learning (PBL)

Os recursos tecnológicos podem oferecer ensino-aprendizagem quando aliados a metodologias participativas de ensino do tipo Aprendizagem Baseada em Projeto (*Project or Problem-Based Learning – PBL*), o que vem melhorando a qualidade dos processos de aquisição de conhecimento(Bereiter & Scardamalia, 2000).

Essa vem ocorrendo, principalmente, por envolver os alunos nas deliberações referentes a aprendizagem, submetendo-os a resolução de problemas reais, e por promover o desenvolvimento de habilidades necessárias ao desempenho funcional. (Nobre, Loubach, Cunha, & Dias, 2006).

A PBL está associada às teorias construtivistas, em que o conhecimento não é absoluto, e sim construído pelo estudante por meio de seu conhecimento pregresso e sua percepção global, dimensionando a necessidade de aprofundar, amplificar e integrar o conhecimento(Brandão et al., 1998).

Os efeitos do uso de metodologia ativas são constatados em estudos integradores de resultados de sua aplicação como no artigo "*Development of competences while solving real industrial interdisciplinary problems: a successful cooperation with industry*" (Lima, et al. 2017), onde os autores mostram por meio de uma revisão sistemática, resultados que ratificam que as metodologias ativas têm contribuído com a formação em engenharia de produção.

Através da engenharia dos requisitos, será possível transcrever estes conceitos para a escrita da Plataforma apresentada neste artigo.

2.2 - Engenharia de Requisitos

A ER está relacionada à identificação de metas e objetivos a serem atingidas pelo *software* a ser construído, assim como à operacionalização de tais metas e objetivos em serviços e restrições.

Essa área também está interessada no relacionamento desses fatores para fazer uma especificação do comportamento do software e sua evolução ao longo do tempo, e também com o processo de aquisição, refinamento e verificação das necessidades do cliente, para um sistema de software no sentido de se obter uma especificação completa e correta dos requisitos de software. Os requisitos guiam as atividades do projeto e normalmente são expressos em linguagem natural e modelagem, tal como a UML para que todos possam obter o entendimento do que será construído. (Carrillo de Gea *et al.*, 2011)

2.3 – UML - Linguagem de Modelagem Unificada

A UML (*Unified Modelling Language* – Linguagem de Modelagem Unificada) surgiu, nos últimos anos, da união de métodos anteriores para análise e projeto de sistemas orientados a objetos e em 1997 passou a ser aceita e reconhecida como um padrão mundial de notação para modelagem de múltiplas perspectivas de sistemas de informações pela OMG ("*Object Management Group*") .

A UML define um conjunto básico de diagramas e notações que permitem representar as múltiplas perspectivas (estruturais / estáticas e comportamentais / dinâmicas) do sistema sobre análise e desenvolvimento. Apoiam no melhor entendimento do sistema. (Costa, 2001)

3 Métodos

Esta pesquisa é do tipo exploratório via estudo de caso com abordagem qualitativa. Foi utilizada a abordagem exploratória, pois a literatura sobre plataformas aplicadas a avaliação de resultados PBL são escassos, e até o momento do estudo não foram encontrados trabalhos com esta especificação, apenas fatores a serem levados em consideração no momento de avaliar o processo via PBL. O local do estudo foi a Universidade de Brasilia-DF-Brasil. O objeto do estudo foi a forma de condução da difusão de resultados PBL, desenvolvida no curso de engenharia de produção.

Foram levantados os resultados no período de 4 meses no acompanhamento dos principais *stakeholders*. Os professores envolvidos observaram as necessidades de cada um dos participantes para que a metodologia ativa fosse implantada. Entrevistas abertas individuais com os participantes foram realizadas para saber seu *feedback* durante e depois da participação. Com os resultados, foi realizado um estudo de caso explicando os principais requisitos da Plataforma e seus resultados, assim como avanços futuros.

4 Desenho da Plataforma Unificada de Metodologia Ativa (PUMA)

A Plataforma Unificada apresenta os requisitos que será desenvolvido e automatizado no processo de avaliação dos alunos e do processo das disciplinas de Projeto de Sistemas de Produção – PSP, integrado às ferramentas de avaliação da Universidade, a fim de mensurar a eficácia da abordagem de ensino atualmente utilizada no curso de Engenharia de Produção, com base no PBL.

Esta automatização permeará o processo desde a captação dos agentes externos (*stakeholders*) com a busca de problemas reais a serem resolvidos pelos alunos das disciplinas de PSPs, até a avaliação e evolução das competências transversais e técnicas dos alunos em todas as 7 disciplinas de projetos.

O ciclo de vida do *software* é composto por várias fases, sendo que o processo de desenvolvimento define as atividades de construção de *software*, responsável pelo desenvolvimento do produto que será alvo deste trabalho.

Com ele, visa produzir um *software* de alta qualidade que atenda ou exceda as expectativas, dentro do tempo, prazos e custo, com base em um bom planejamento de projeto.

Para gerenciar esse nível de complexidade, o mercado aborda uma série de modelos ou metodologias, sendo que uma delas ganhou muita força nos últimos anos devido à necessidade do mercado em atender às demandas dos clientes e seus projetos de maneira mais dinâmica, flexível e com maior produtividade, sendo este a Metodologia ágil.

O desenvolvimento ágil utiliza uma abordagem de planejamento incremental e iterativa. Cada iteração normalmente dura de 1 a 4 semanas, chamados de Sprint, e inclui todas as disciplinas de desenvolvimento de software, tal como, gestão de projeto, levantamento de requisitos, análise e modelagem, desenvolvimento de código, teste de software e implantação. Ao final de cada Sprint deve haver uma entrega ao cliente, que inclua um conjunto de novas funcionalidades, uma nova versão de software. (Gloger, 2010)

Com base neste processo e práticas ágeis e objetivos aqui descrito, pretende-se o desenvolvimento da Plataforma, de acordo com a modelagem apresentada na seção de resultados.

Por sua vez, o levantamento de requisitos é uma das fases mais importantes do processo e resultará no desenvolvimento da Plataforma. A linguagem A Engenharia de Requisitos é um processo considerado por diversos autores como a parte mais crítica no desenvolvimento *software*, uma vez que a qualidade do produto final depende fortemente da qualidade desses requisitos. (Ferguson & Lami, 2006)

A linguagem natural aliada a uma a modelagem, permite um melhor entendimento e detalhadamente dos requisitos.

Através da UML – Linguagem de Modelagem Unificada, linguagem padrão para a elaboração da estrutura de projetos de software que é muito utilizada na construção de produto de *software* e apoia na identificação e escrita dos requisitos. São vários os diagramas utilizados que podem apoiar no desenvolvimento do sistema, entre eles o diagrama de caso de uso, que pode descrever todas as funções de um sistema de *software*, sendo base ainda para os demais diagramas que podem ser elaboradoras. O diagrama de caso é uso, basicamente é composto por três elementos:(Hu, Deng, & Hong, 2011)

- Atores: Representado por um boneco, pode ser um usuário do sistema, um ser humano ou computacional.
- Caso de uso: Representado por uma Elipse e define as funcionalidades do sistema.
- Relacionamentos: Representados por setas e definem os relacionamentos entre atores e casos de uso que irão interagir com o sistema.

Este diagrama documenta e apoia no entendimento mais simplista, sobre o sistema a ser desenvolvimento tanto do ponto de vista do usuário quanto do ponto de vista da equipe de desenvolvimento, equalizando e apoiando no entendimento e necessidade a ser desenvolvida. A seção de resultados, apresentará a modelagem do diagrama de caso de uso desenvolvida para a Plataforma Unificada de Metodologia Ativa.

5 Resultados

Com base nos conceitos apresentados neste artigo, foi possível um levantamento de requisitos junto aos stakeholders, para entendimento e escrita dos requisitos a nível macro, que será base para a implementação da Plataforma. A Figura 2, representada no diagrama de caso de uso da Plataforma e retrata as funcionalidades a serem desenvolvidas no projeto e suas interações com os atores, conforme explicação dos requisitos, detalhados abaixo:

Os agentes externos, serão representados por qualquer pessoa, que queiram levar a Universidade problemas reais a serem resolvidos pelos alunos através das disciplinas de PSP's. Neste contexto a Plataforma irá permitir a divulgação da oferta e ainda a solicitação de envio de projetos de forma automatizada, ao qual será preenchido um formulário e enviado à análise posterior da secretária na triagem dos projetos. Permitirá ainda que se mantenha uma base de agente externos para posterior divulgação dos resultados e pesquisas realizadas através das disciplinas e universidade.

As secretárias, serão representadas por agentes administrativos da Universidade que irão apoiar na triagem dos projetos enviados pelos Agente Externos (Stakeholders).

Os alunos, terão acesso a área restrita da Plataforma a fim de acompanhar seus históricos e evolução nas disciplinas de PSPs, a ainda será utilizado como ferramenta de avaliação, para os métodos apresentados pela Universidade e disciplinas, conforme apresentado abaixo:

- Emissão de relatórios, com histórico das disciplinas, notas, sumarização das competências transversais, Avaliação por pares ou *peer review*, Avaliação dos docentes e qualquer necessidade de informações advindas da Plataforma.
- Preencher Avaliação *Peer*, irá permitir a avaliação dos seus colegas de sala, na participação dos projetos realizados em grupo, propostos pelas disciplinas. Essas avaliações poderão fazer parte da composição das notas das disciplinas.
- Preencher avaliação docente e Avaliar a metodologia de Ensino, a fim de captar a percepção dos alunos quanto aos métodos e didáticas utilizadas nas disciplinas, pelos docentes.
- Divulgação das notas dos alunos que irá se integrar com a *Moodle*. Esta ferramenta já é consolidada na interação dos alunos e professores da Universidade.

Os monitores e professores, irão agregar as funcionalidades dos alunos, mais as funcionalidades abaixo descritas:

- Manter avaliação transversal, poderá pesquisar, incluir, alterar e excluir as competências que serão trabalhadas ao longo das disciplinas PSPs podendo ser customizáveis nos itens de avaliação, pelos professores na avaliação dos alunos. Ao final das disciplinas de PSPs, serão analisados a evolução dos alunos nas competências traçadas e se os objetivos esperados com a aplicação da metodologia de PBL, foram alcançadas, para futuras melhorias a serem aplicadas no programa.

- Manter avaliação *Peer*, poderá pesquisa, incluir, alterar e excluir, itens a serem utilizados na avaliação em grupos nas disciplinas de PSPs.
- Manter menção, poderá pesquisar, incluir, alterar e excluir as menções de cada aluno a cada disciplina de PSP. Fará também integração com o matricula web, sistema da universidade que mantém as notas de todas as disciplinas do curso de graduação da engenharia de produção.

Coordenador do PSPs, irão agregar todas as funcionalidades dos professores e alunos, mais as funcionalidades, abaixo descritas:

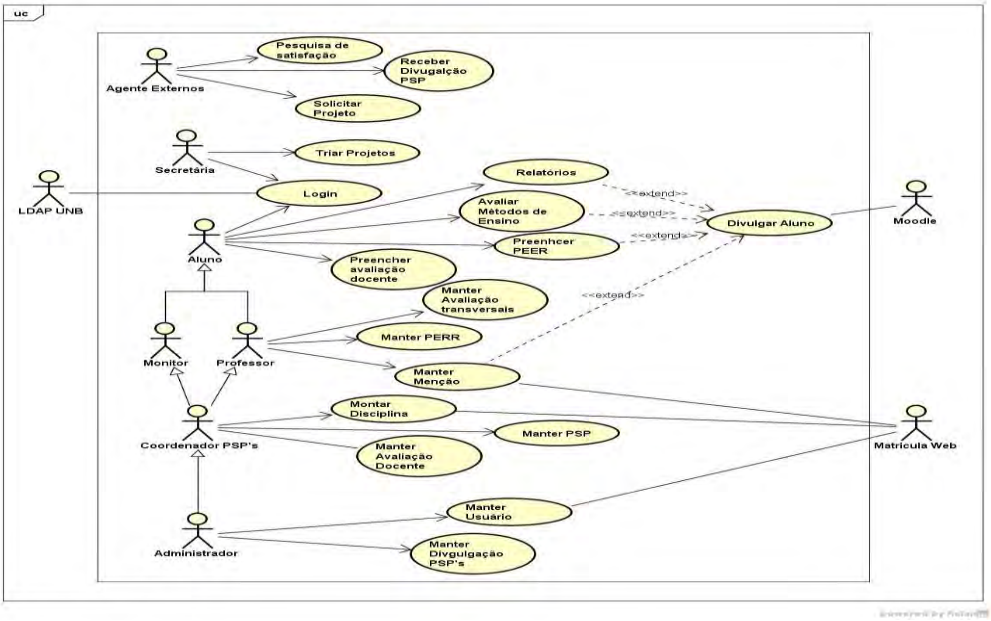
- Montar disciplinas, poderá agregar os projetos advindos dos *stakehoders* as 7 disciplinas ofertadas nos PSPs, de acordo com a sua área de atuação, além de configurar os horários das disciplinas, docentes, local e ementa abordada.
- Manter Avaliação Docente, poderá pesquisar, incluir, alterar e excluir itens para ser utilizado na avaliação dos docentes que serão preenchidos pelos alunos da disciplina.
- Montar PSPs, poderá pesquisar, incluir, alterar e excluir, informações de cada uma das 7 disciplinas ofertadas na Universidade.

Administrador, irá agregar todas as funcionalidades do sistema, além das funcionalidades abaixo especificadas:

- Manter Usuário, poderá conceder e retirar os acessos as funcionalidades da Plataforma, conforme seus devidos papéis e responsabilidades descritas pelos atores do sistema.
- Manter Divulgação PSPs, será utilizado para pesquisar, incluir, alterar e excluir, divulgações para promover as disciplinas e captação de projetos e problemas reais a serem advindos dos agentes externos e trabalhos nas disciplinas.

A Plataforma será restrito aos atores apresentados no diagrama da figura 1, sendo que será integrado ao sistema de login da Universidade (LDAP UNB) a fim de unificar e aproveitar os registros já cadastrados.

Figura 1 - Diagrama de caso de uso da Plataforma



Fonte: Própria

Com base na proposta apresentada, espera-se alcançar uma integração e avaliação em 360° graus, conforme apresenta a figura 2, utilizando a tecnologia para apoiar a acompanhamento, avaliação e evolução de todas as partes interessadas neste processo.

Figura 2 – Avaliação em 360° PSPs

Fonte: Própria

Busca-se assim com a Plataforma, ter um acompanhamento semestral dos discentes e docentes e ir atuando de forma proativa, com ações de melhoria nas necessidades que forem sendo apresentadas, conforme listados abaixo:

- Aumento da captação dos agentes externos (*stakeholders*), para uma elevação e diversificação dos temas abordados das disciplinas de PSPs;
- O acompanhamento do desempenho e da evolução dos alunos ao longo das disciplinas de PSPs com base nas avaliações transversais realizadas;
- Triagem dos projetos com intuito de selecionar aqueles mais pertinentes a pesquisas e necessidades da Universidade de Brasília;
- Obtenção da coleta de *feedbacks* de alunos, professores e *stakeholders* para o aprimoramento das disciplinas.
- Emissão de relatórios e indicadores das disciplinas de PSPs, discentes e docentes;
- Integração entre os sistemas da Universidade de Brasília, a fim de evitar retrabalhos e duplicidades de base;
- Iteração entre os alunos e professores, por meio da plataforma.

6 Conclusão

A idealização da Plataforma que viabilize a automatização de todos o processo de avaliação, acompanhamento e competências transversais dos alunos visando uma maior praticidade, segurança e eficiência no tratamento das informações advindas da implementação do método "*Project Based Learning*" (Aprendizagem Baseada em Projetos) no curso de Engenharia de Produção da Universidade de Brasília obteve excelente aceitação e satisfação por parte dos envolvidos comprovando o sucesso durante a tradução dos anseios e das expectativas para o produto final e o cumprimento dos requisitos determinados durante a execução do desenvolvimento do sistema.

Os insumos obtidos por esse sistema auxiliarão não só os envolvidos na implementação do método no curso de Engenharia de Produção da Universidade de Brasília, essas informações serviram de base para toda comunidade acadêmica que estuda a utilização desse método em diversas áreas de conhecimento.

Como trabalhos futuros, pretende-se, apresentar o sistema implementado e todos os benefícios e dificuldades que serão advindos desta implementação, que está sendo possível a sua realização através do Programa Aprendizagem para o 3º Milênio (A3M) do CEAD/UnB, com o Patrocínio de 25mil na realização do projeto. No momento a plataforma encontra-se em execução, obedecendo o cronograma estipulado pelo A3M. Espera-se que uma vez concluída os resultados sejam disponibilizados a todos os participantes facilitando a construção progressiva da aprendizagem.

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The impact of Active learning on Preliminary Course Concept (CPC) and in the Engineering Student Satisfaction

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Abstract

Garantir uma educação de qualidade é um desafio no contexto de mudanças como a globalização, as novas tecnologias, e a necessidade de inclusão e diversidade. As instituições de ensino superior (IES) no Brasil são frequentemente monitoradas pelo governo através do INEP (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira), para ajudar a orientar suas ações e avaliações relacionadas ao Ensino Superior, uma das etapas é a Avaliação Institucional do Sistema Nacional de Avaliação do Ensino Superior (ENADE). No entanto, o índice ENADE representa 20% e o Indicador de Diferença de Desempenho Observado e Esperado (IDD) em 35%. O IDD é a comparação do grau ENADE da instituição com a média das outras instituições. Isto é, embora o ENADE seja de 20%, também influencia outros 35% através do IDD. Composição do resto da nota é o professor que representa 30% e Infraestrutura e organização didático-pedagógica com 15% do valor do total do CPC (Conceito de Curso Preliminar). Assim, a compreensão do papel da metodologia ativa nos outros fatores é importante para estabelecer seu escopo na formação do aluno. Desta forma, o objetivo deste trabalho é entender o impacto da metodologia ativa nas dimensões do CPC. Para alcançar esse resultado, foi realizado um estudo exploratório com abordagem quantitativa com análise multivariada. Os dados foram coletados através de um questionário validado (Cronbach's Alpha α = 0.88), com 343 alunos do curso de Engenharia de Produção da Universidade de Brasília (EPR-UnB). Os resultados sugerem que o método PBL é o fator que influencia o desempenho e a satisfação dos alunos, sendo que ele também influencia em 18,9% a organização didático-pedagógica.

Keywords: Active learning, Student performance, SmartPLS, Structural equations

O Impacto da Aprendizagem Ativa no Conceito de Curso Preliminar (CPC) e na Satisfação dos Estudantes de Engenharia

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Resumo

Garantir uma educação de qualidade é um desafio no contexto de mudanças como a globalização, as novas tecnologias, e a necessidade de inclusão e diversidade. As instituições de ensino superior (IES) no Brasil são frequentemente monitoradas pelo governo através do INEP (Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira), para ajudar a orientar suas ações e avaliações relacionadas ao Ensino Superior, uma das etapas é a Avaliação Institucional do Sistema Nacional de Avaliação do Ensino Superior (ENADE). No entanto, o índice ENADE representa 20% e o Indicador de Diferença de Desempenho Observado e Esperado (IDD) em 35%. O IDD é a comparação do grau ENADE da instituição com a média das outras instituições. Isto é, embora o ENADE seja de 20%, também influencia outros 35% através do IDD. Composição do resto da nota é o professor que representa 30% e Infraestrutura e organização didático-pedagógica com 15% do valor do total do CPC (Conceito de Curso Preliminar). Assim, a compreensão do papel da metodologia ativa nos outros fatores é importante para estabelecer seu escopo na formação do aluno. Desta forma, o objetivo deste trabalho é entender o impacto da metodologia ativa nas dimensões do CPC. Para alcançar esse resultado, foi realizado um estudo exploratório com abordagem quantitativa com análise multivariada. Os dados foram coletados através de um questionário validado (Cronbach's Alpha α = 0.88), com 343 alunos do EPR / UnB. Os resultados sugerem que o método PBL é o fator que influencia o desempenho e a satisfação dos alunos, sendo que ele também influencia em 18,9% a organização didático-pedagógica.

Palavras-chave: aprendizagem ativa, desempenho do aluno, SmartPLS, equações estruturais

1 Introdução

O novo contexto da educação marcado pelas modernas tecnologias, a globalização e os perfis diversificados dos discentes traçaram um desafio para as Universidades. Lima *et al.* (2017), explica que diversos currículos dos cursos de Engenharia no Brasil sofreram mudanças para se adequarem aos propósitos de inclusão, diversidade, uso de tecnologias, sobretudo para cumprir as "Diretrizes de Educação de Engenharia", propostas pelo governo brasileiro.

Para garantir que se cumpram as diretrizes preconizadas pelo Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira -INEP, a cada três anos ocorre o ENADE (Exame Nacional de Desempenho dos Estudantes), uma avaliação dos cursos de graduação que busca mensurar a qualidade do ensino superior por meio do cumprimento dos conhecimentos exigidos pelas Diretrizes Curriculares Nacionais (DCN´s). Segundo Souza, *et al*. (2016), O ENADE constitui um indicador importante na avaliação do critério geral do CPC (Conceito Preliminar de Curso). O CPC é um indicador de qualidade e seus dados subsidiam os atos de "Renovação de Reconhecimento" dos cursos de graduação.

Em uma tentativa de integrar as diretrizes estabelecidas e os novos desafios da educação, o curso de Engenharia da Produção da Universidade de Brasília (EPR-UnB), desde 2011, adotou a metodologia ativa por meio *Project Based Learning* – PBL. De acordo com o último resultado divulgado do ENADE, o curso de EPR/UnB alcançou o 2º lugar geral dentre todos os cursos de Engenharia de Produção existentes no Brasil.

Sugere-se desse modo, a metodologia ativa contribuiu para o resultado positivo do ENADE inferindo-se que o aprendizado ativo reflete em notas excelentes para o padrão estabelecido pelo governo. Porém o CPC não é formado apenas da nota do ENADE, ainda existem fatores que influenciam em seu conceito final. Estes fatores estão divididos em três eixos: i. Desempenho dos Estudantes: (Nota do ENADE + Nota do Indicador da Diferença entre os Desempenhos Observado e Esperado (IDD); ii Corpo Docente: informações sobre a titulação e regime de trabalho dos docentes vinculados aos cursos avaliados; e iii Percepção Discente sobre as Condições do Processo Formativo, que contempla subitens como: organização didático-pedagógica, infraestrutura e instalações físicas e oportunidades de ampliação da formação acadêmica e profissional.

O desempenho dos estudantes é equivalente a 55% do total da nota, sendo a nota do ENADE responsável por 20% e o IDD por 35%. O IDD é a comparação da nota ENADE da instituição com a média das demais instituições. Ou seja, apesar do ENADE ser 20%, influencia também em outros 35% por meio do IDD. Compondo o restante da nota está o corpo docente representando 30% e Infraestrutura e organização didático-pedagógica com 15% do valor da nota total do CPC. Assim compreender o papel da metodologia ativa nos demais fatores é importante para estabelecer seu alcance na formação do discente.

Muitos estudos (Blackburn,2017; Zhou, *et al.,* 2016; Gunter & Alpat; 2017), comprovam a valia do uso das metodologias ativas na aprendizagem do aluno, porém compreender sua interação com os demais fatores que influenciam a nota final do CPC é importante para ter uma visão do alcance de seu uso na educação. Assim, o problema deste estudo é saber: qual o impacto da metodologia ativa, na Infraestrutura, organização didático-pedagógica e satisfação dos alunos do curso de Engenharia de Produção da UnB?

A satisfação do aluno é um fator fundamental para compreender a percepção das ações empregadas pela EPR-UnB, favorecendo a atualização do currículo e o planejamento de ações corretivas para melhoria da prática docente. Deste modo o objetivo deste trabalho é entender o impacto da metodologia ativa nas dimensões do CPC. Para alcançar o objetivo deste estudo foi realizada uma pesquisa exploratória por meio das equações estruturais.

2 Fundamentação teórica

2.1 Conceito Preliminar de Curso e o ENADE

No ano de 2004, o governo brasileiro criou, por meio da Lei 10.861, o Sistema Nacional de Avaliação do Ensino Superior (Sinaes). Segundo Moreira (2010), o Sinaes é composto por diferentes avaliações: a autoavaliação das instituições de ensino, o ENADE e as avaliações externas dos cursos de graduação, realizada por uma comissão de especialistas.

O ENADE avalia o rendimento dos concluintes dos cursos de graduação, em relação aos conteúdos programáticos, habilidades e competências adquiridas em sua formação. Ele faz parte de uma série de indicadores que formam uma medida maior chamada Conceito Preliminar de Curso (CPC). Usualmente na mídia em artigos científicos se discutem a Nota do ENADE das instituições. Embora as outras dimensões pesem menos no processo da nota, são de extrema importância na instituição, uma vez que representam 45% da nota e exerce efeitos indiretos em outros fatores. O quadro 1 apresenta as variáveis que compõe o CPC.

QUADRO 1 – Composição do CPC e pesos de suas dimensões e componentes

DIMENSÃO	COMPONENTES	PESOS	%
Desempenho dos Estudantes	Conceito Enade	20,0%	55%
	IDD (Valor agregado)	35,0%	
Corpo Docente	Doutores	15,0%	30%
	Mestres	7,5%	
	Regime de Trabalho	7,5%	
Infraestrutura e organização didático-pedagógica	Infraestrutura e Instalações físicas	7,5%	15%
	Organização didático-pedagógica	5,0%	
	Oportunidade de ampliação da formação acadêmica e profissional	2,5%	

Fonte: Inep 2017.

Os cursos de Engenharia da Universidade de Brasília têm a quase totalidade de seus professores com doutorado e com carga horária completa e dedicação exclusiva a Instituição, cumprindo, portanto, com o fator corpo docente, representado por estas perguntas. Por este motivo as dimensões infraestrutura e organização didático-pedagógica são as factíveis de serem mensuradas neste trabalho.

2.2 Formulação do modelo a ser pesquisado

Foi utilizado um dos instrumentos do CPC conhecido como questionário do estudante. Este questionário é de preenchimento obrigatório no momento que o estudante vai confirmar sua inscrição realizada pela sua instituição previamente e assim conhecer seu local de prova. São selecionados os alunos que tenham mais 80% integralizado para serem inscritos. Como a EPR-UnB possui cerca a totalidade de seus professores com dedicação exclusiva e título de doutor, este fator não seria discriminante no modelo, sendo, portanto, desprezado. Assim, utilizou-se as três sub dimensões dos fatores Infraestrutura e organização didático-pedagógica (Infraestrutura e Instalações físicas, organização didático pedagógicas e oportunidade de ampliação da formação acadêmica profissional). Adicionalmente foram contempladas as variáveis satisfação e metodologia PBL, conforme figura 1.

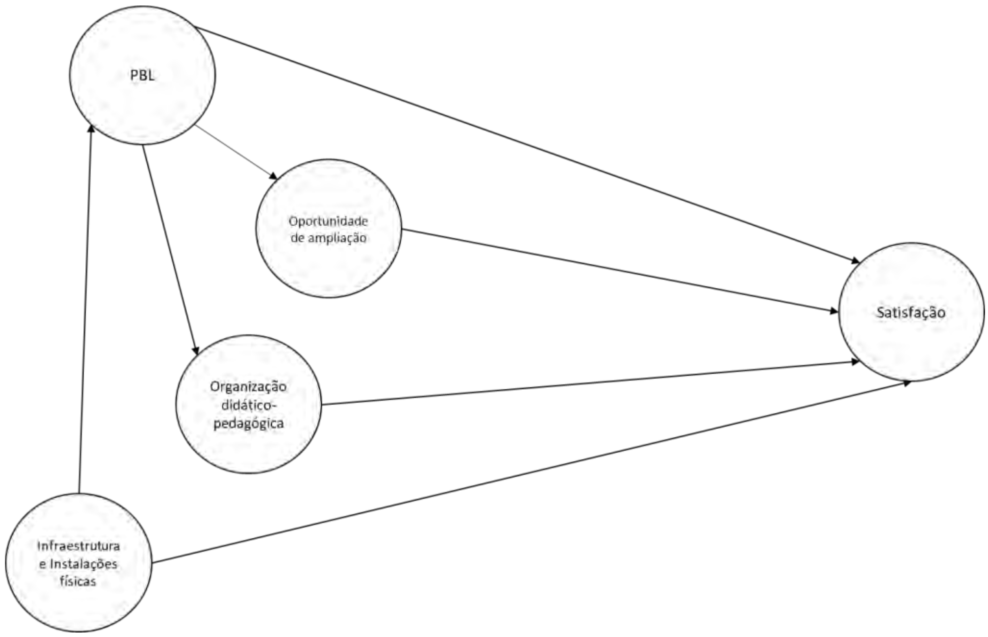

Figura 1. Modelo de Equações Estruturais - Fonte: Elaborado pelo autor

As relações entre PBL e as variáveis foram estabelecidas pela literatura (Borochovicius & Tortella, 201; Mariano et al., 2017; Souza et al., 2016;). Assim espera-se que a metodologia ativa via PBL influencie a oportunidade de ampliação de atividades do aluno em sua formação estudantil, a didático-pedagógica -organizacional e a satisfação. Enquanto a Infraestrutura e instalações físicas influenciam o PBL, uma vez que possuir condições facilitadoras é importante para a realização dos projetos, somo mesa, espaço, etc. Por último, todos fatores influenciam a satisfação.

3 Métodos

Esta pesquisa é do tipo exploratória. A abordagem para tratamento dos dados foi quantitativa por meio das equações estruturais. O local de estudo foi a Universidade de Brasília, localizada no Distrito Federal, Brasil. O objeto de estudo foi a percepção dos alunos em relação aos critérios de infraestrutura e organização didático-pedagógica do curso de Engenharia de Produção.

O Instrumento de coleta de dados foi um questionário adaptado do questionário do aluno, que compõe a nota do CPC e consta de 66 questões. Adicionalmente foram incluídas questões sobre metodologias ativas e satisfação com o curso. Foi realizado um censo em 2016 com todos os alunos de Engenharia de Produção da Universidade de Brasília. O questionário foi disponibilizado via plataforma *Moodle*.

O software para tratamento dos dados foi o *SmartPLS* 3.16, que calcula o grau de interação entre as variáveis via correlações, regressões e caminhos (*path*). Chin (1998), explica que as equações estruturais baseadas em variância são ideais para construção de modelos de pesquisa via questionários.

4 Resultados e Análises

As análises via equações estruturais cumprem três passos, conforme Figura 2. A etapa 1 de descrição do modelo é realizada na literatura. Neste estudo em especial quem guiou o instrumento foi o próprio questionário do CPC, especificamente questionário do estudante. A literatura contribuiu para estudo das relações do modelo e escalas de medida para PBL e satisfação.

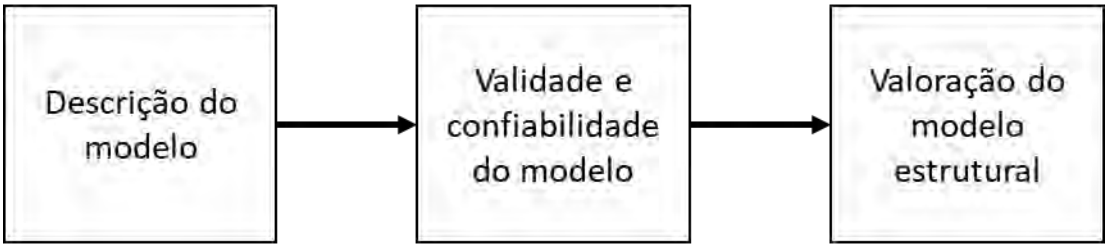

Figura 2. Etapas análise PLS-SEM - Fonte: Elaborado pelo autor

A etapa 2 assegura a confiabilidade do modelo por meio de dois índices: confiabilidade de item e interna. Os testes forma realizados e o *Cronbach's Alpha* α = 0.88. Ramirez, Mariano & Salazar (2014), estabelecem valores superiores a 0,7 para garantir confiabilidade. Após os testes de confiabilidade, são realizados dois testes de validade (validade convergente e discriminante). Todos os testes foram satisfatórios.

Por último se realizou um teste de Inflação Média da Variância (VIF) para assegurar que não existia multicolinearidade entre os dados. Também foi aceito.

Finalmente a etapa 3, mensuração do modelo estrutural, que aparece descrito da figura 3:

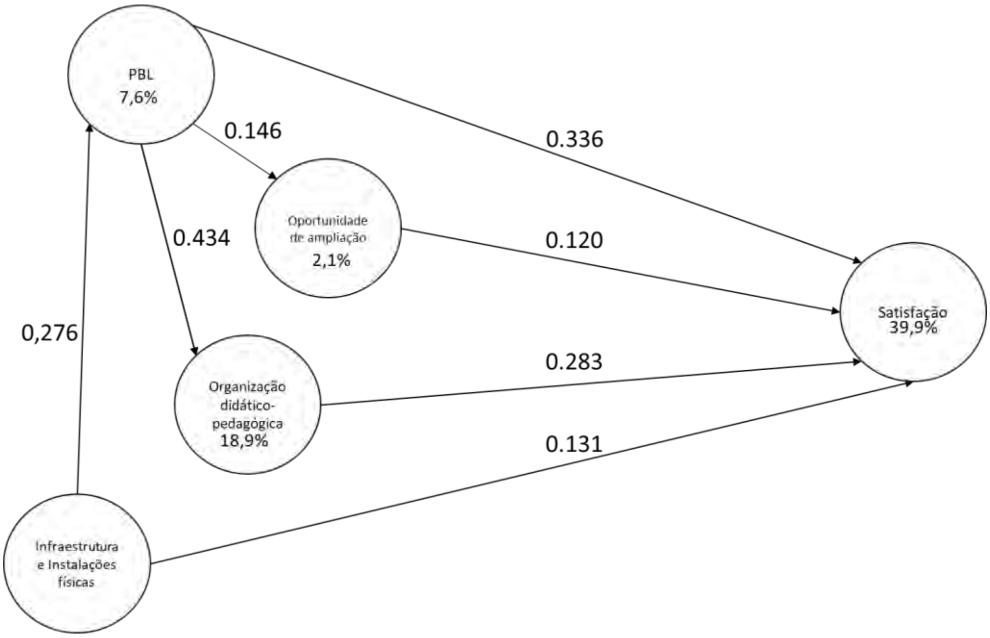

Figura 3. Valoração do modelo estrutural - Fonte: Elaborado pelo autor. Extraído do *Software SmartPLS* 3

O modelo estrutural calculado oferece dois índices: Beta e o Coeficiente de Determinação. Os Betas explicam com que impacto uma variável influência sobre a outra e o Coeficiente de Determinação, explica em quanto as variáveis independentes explicam a dependente onde chega a seta. Segundo Ramírez, Mariano & Salazar (2014), os valores para que um beta seja significante é 0.2 e para que o R^2 (Coeficiente de Determinação) é a partir de 13%. Embora comparado a modelos econométricos seja um valor baixo, para modelo de equações estruturais via PLS-SEM é aceitável.

Pode-se perceber que a variável PBL influência a organização didático-pedagógica em 18,9% e com 0,43 graus, comprovando sua importância também nesta dimensão. Entretanto, para a oportunidade de ampliação acadêmica que resulta ser envolvimento em extensão, pesquisa, estágio e intercambio o fator não foi significativo (2,1%). Acredita-se que devido ao caráter integrador de conhecimentos das disciplinas, as visitas aos clientes dos projetos e a consecução do mesmo acabe por tomar um tempo extra do aluno, não fomentando (por meio da falta de tempo), outras atividades. Mas é importante ressaltar que ainda assim, dentro do PBL na EPR-UnB, os alunos realizam pesquisas frequentes e publicam com os resultados de seus trabalhos, realizam extensão ao atender a comunidade via projetos e atuam no mercado ao atender estes *stakeholders*. A infraestrutura e instalações físicas, segundo (Borochovicius & Tortella, 2011) influencia o PBL, assim que a relação foi colocada inversamente. Porém, não se comprovou nesta ocasião influência desta variável sobre o PBL. Acredita-se que o fato de trabalhar com projetos faz com que o aluno atue com ferramentas cotidianas como seu computador pessoal, softwares, passando desapercebida a importância das salas de PSPs com mesas circulares para os grupos, entre outros.

Por último foi estabelecido a relação de todas as variáveis com satisfação do aluno e se conseguiu predizer nesta ocasião 39,9%, sendo a metodologia ativa PBL o que mais influi (0.336 graus), seguido de organização didático-pedagógica com 0.283 graus. Sendo o PBL também influenciador da variável organização didático-pedagógica, pode-se perceber que o PBL também é responsável por melhorar a percepção dos demais fatores do CPC calculados neste modelo.

5 Conclusões

O problema desta pesquisa foi conhecer qual o impacto da metodologia ativa, na infraestrutura, organização didático-pedagógica e satisfação dos alunos do curso de Engenharia de Produção da UnB. Os resultados obtidos sugerem que a metodologia ativa possui impactos sobre a organização didático-pedagógica e satisfação dos alunos. A relação da metodologia ativa com a Infraestrutura, foi desenhada de maneira inversa, sendo as instalações como influenciadora. Nesta ocasião não se encontrou resultados significativos. O mesmo aconteceu para a influência da variável PBL em oportunidade de ampliação acadêmica, que se revelou baixa (2,1%). Aconselha-se refletir sobre os aspectos conceituais das atividades para permitir experiências do aluno fora da metodologia ativa.

Assim o objetivo deste trabalho que foi entender o impacto da metodologia ativa nas dimensões do CPC foi alcançado. Porém existem ainda cerca de 60% da satisfação do aluno que não foi mapeada, sendo, portanto, uma futura linha de pesquisa.

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Proposal of insertion of gamification elements in the semester projects of a Computer Engineering program

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Abstract

Engineering programs are being changed to enable more engagement and motivation of students, and some of these initiatives are focused on active methodologies and more recently, on gamification. During the last 10 years, students of an engineering program in a University located on the Greater ABC area in São Paulo are challenged to develop projects with increasingly demanding difficulties during their 5-year program. The engagement with of these projects helps the development of technical and personal competencies, including the abilities to make oral and written presentation, to work in teams and manage projects. Considering the success obtained during these years and searching for different ways of enhancing the engagement of the students and reducing dropouts, this paper aims at presenting a proposal of gamification of the projects during the first two years of the Computer Engineering program. It also aims at verifying the impacts of this change in the student's engagement with the program and the institution. Only one of the classes is facing gamification and the other will remain the same. In the middle and at the end of the semester, students are answering to a questionnaire regarding the dynamics being used, and the results of the project are being considered. Identify if gamification of the projects motivates the students and if the results are positively affected or not should be answered for this paper.

Keywords: Active Learning; Engineering Education; Symposium Information; Project Approaches.

Proposta de inserção de elementos de gamificação nos projetos semestrais de um curso de Engenharia de Computação

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Abstract

Os cursos de engenharia estão, cada vez mais, sendo modificados de modo a possibilitar maior engajamento e motivação dos alunos e algumas dessas iniciativas enfocam o uso de metodologias ativas e mais recentemente, a gamificação. Ao longo dos últimos 10 anos, alunos do curso de engenharia de computação de uma instituição de ensino comunitária da Grande São Paulo são desafiados a desenvolver projetos semestrais com grau de dificuldade crescente ao longo dos cinco anos de curso. O desenvolvimento desses projetos auxilia no desenvolvimento de competências técnicas inerentes à profissão (Engenharia da Computação) e competências pessoais, como capacidade de comunicação oral e escrita, capacidade de trabalhar em equipes e de gerenciar projetos. Considerando o sucesso obtido nos últimos anos e buscando formas de aumentar ainda mais o engajamento dos alunos com o curso e de reduzir a evasão, este trabalho tem o intuito de apresentar uma proposta de aplicação de elementos de gamificação nos projetos semestrais dos dois primeiros anos do curso de engenharia de computação, a fim de verificar os impactos dessa mudança no que tange o envolvimento dos alunos com o curso e que mudanças são verificadas em termos de competências técnicas e pessoais. A inclusão dos elementos de gamificação será feita em apenas uma das turmas do curso, sendo que as outras manterão o modelo atual. No meio e ao final do semestre, nos momentos de avaliação das entregas parcial e final do projeto, os alunos deverão responder a um questionário sobre a dinâmica que está sendo usada e os resultados do projeto também serão considerados. Dessa forma, pretende-se identificar se os elementos de gamificação motivam e, caso haja realmente motivação, se os resultados de projetos são afetados positivamente ou não por essa nova dinâmica.

Keywords: Active Learning; Engineering Education; Symposium Information; Project Approaches.

1 Introdução

Muito se tem discutido sobre a formação de engenheiros no Brasil e no mundo e sobre as diferentes maneiras de se realizar esta tarefa (Laudares & Ribeiro, 2000; Silveira, 2005). O uso de diferentes metodologias de ensino nos currículos de engenharia, conta com a utilização de Aprendizagem Baseada em Problemas, Aprendizagem Baseada em Projetos, Aprendizagem Colaborativa (Carvalho & Lima, 2006), entre outras, e gerou inúmeros trabalhos científicos ao longo dos últimos vinte anos. Neste trabalho, apresentaremos uma proposta que prevê a inserção de elementos de gamificação em um processo já estabelecido de desenvolvimento de projetos semestrais em um curso de engenharia de computação. Para isso, será apresentado um referencial teórico voltado para o uso de projetos e suas relações com o desenvolvimento de competências interpessoais e engajamento com o ambiente e a comunidade. Em seguida, o artigo trata da questão da gamificação e sua utilização na educação para finalmente ser apresentada a proposta que está em fase de implantação e os estudos que estão sendo realizados sobre esta abordagem.

Esta pesquisa é um estudo exploratório que tem como objetivo identificar se a divulgação pública dos projetos semestrais de alunos de engenharia é, de fato, bem aceita pelos estudantes, qual a melhor opção para divulgação (na visão dos estudantes) e se eles relacionam o fato de as atividades desenvolvidas por eles durante seu período acadêmico estarem mais visíveis com algum ganho para seu projeto ou para seu currículo. Não serão apresentados resultados conclusivos, uma vez que o projeto está em andamento, mas a metodologia e os resultados esperados serão detalhados.

2 Fundamentação

A necessidade de se formar engenheiros capazes de lidar com os novos problemas que lhe são apresentados no século XXI, coloca a Aprendizagem Baseada em Projetos (PjBL) como forma alternativa à formação baseada em aulas expositivas centradas no docente. Esta abordagem, além de poder atender a necessidades de formação técnica, fundamental para os engenheiros, também tem se mostrado viável para o desenvolvimento de competências interpessoais (soft skills) necessárias às novas relações de trabalho (Pereira et al, 2013).

A PjBL tem sido usada nos cursos de engenharia também com o intuito de envolver os alunos de forma mais ativa com sua formação. Este envolvimento deve ser de forma interdisciplinar e também deve estar ligado à solução de algum problema, preferencialmente, aberto (Kolmos, 1996). Este problema pode ser resolvido de diferentes formas, e sua solução fica a cargo dos grupos de estudantes envolvidos, criando dessa forma, um sentido de pertencimento nos estudantes, pois a maneira de resolvê-lo parte deles e não dos docentes.

Segundo Kolmos e De Graaff (2007), as mudanças para o PjBL têm auxiliado na redução das taxas de evasão, estimulado a motivação dos alunos pela aprendizagem, melhorado o perfil institucional e favorecido o desenvolvimento de novas competências.

Associado ao uso de PjBL, a gamificação vem gradualmente ganhando espaço no contexto educacional e, nos últimos anos, com crescente interesse no ensino superior. A definição de gamificação usada neste trabalho é a de usar mecânicas e técnicas conhecidas de vários tipos de jogos (incluindo jogos de tabuleiro e jogos de computador) com o intuito de aumentar o envolvimento na execução de vários tipos de atividades fora do contexto de jogos, principalmente nas atividades consideradas chatas e rotineiras (Sheldon, 2011).

Segundo Huizinga (1955), o jogo é uma atividade voluntária intencionalmente separada das atividades “mais sérias” do dia-a-dia. Essa atividade envolve o jogador de forma intensa e não precisa ter relação com benefícios materiais, no entanto, exige que o jogador siga determinadas regras e ordens e que jogue em um determinado local e horário.

Pode-se afirmar que ao gamificar o processo de desenvolvimento de um projeto de graduação, os participantes passam a ser jogadores e, como jogadores eles são o foco do jogo, devem se sentir envolvidos, tomar as próprias decisões, perceber seus progressos, receber novos desafios, participar de um ambiente social, ser reconhecidos por suas conquistas e receber feedbacks imediatos. Em resumo, devem se sentir bem (se divertir) cada vez que atingirem determinados objetivos do processo gamificado (do projeto). Se, além do sentido clássico de diversão como entretenimento, assumirmos que diversão é uma recompensa para o cérebro por ter aprendido alguma coisa nova (Koster, 2004), a ligação entre diversão e aprendizagem é a chave para a proposta de gamificação no processo de ensino e, portanto, no processo de desenvolvimento de projetos e na sua exposição pública.

3 Metodologia

O principal objetivo deste trabalho é entender a percepção dos estudantes em relação à mudança provocada no processo de desenvolvimento de seus projetos semestrais com a inserção de um elemento adicional. A abordagem metodológica está baseada nas respostas dadas pelos alunos envolvidos neste processo de mudança.

3.1 Contexto do Estudo

A Escola de Engenharias, Tecnologia e Informação – EETI é uma das unidades da Universidade Metodista de São Paulo. Em 1999, em resposta às mudanças socioeconômicas ocorridas na região do Grande ABC paulista, lançou o curso de Engenharia da Computação e ao longo dos últimos anos vem, paulatinamente, aumentando sua atuação nesta área de formação superior. Em 2017, após iniciar duas novas modalidades, passou a ter cinco opções de cursos de engenharia: Ambiental e Sanitária, Civil, Computação, Eletrônica e Produção.

Os cursos de engenharia têm passado por mudanças nas suas estratégias pedagógicas e, desde 2008, o curso de Engenharia de Computação adota o desenvolvimento de projetos semestrais ao longo dos cinco anos de formação dos estudantes. Dessa forma, além das aulas tradicionais, são desenvolvidas Atividades de

Enriquecimento (Mizukami, 1986) com estratégias de aprendizagem centradas nos estudantes, exigindo do aluno ma atitude mais ativa, colaborativa e empreendedora.

Essa estratégia de desenvolvimento de projeto tem gerado resultados muito positivos em relação ao envolvimento dos alunos com o curso, nas relações interpessoais seja com colegas de sala ou com os docentes e lhes tem dado maior autonomia, pois as atividades relacionadas a projetos demandam a conclusão de tarefas em datas pré-definidas, portanto, um atendimento a prazos bastante rígido.

Anualmente, são realizadas avaliações com os estudantes, em que as condições de ensino, corpo docente, infraestrutura, dinâmica pedagógica, entre outros tópicos, são avaliados pelos docentes e estudantes. Este processo é conhecido como Avaliação Institucional e, nas análises realizadas nos últimos anos, foram identificadas menções à *"pouca visibilidade dada aos projetos"* e à *"vontade de mostrar* [o projeto] *para mais pessoas"*, o que levou à proposta apresentada neste artigo, que contempla a solicitação de criação de uma página do projeto em uma rede social (possibilitando maior visibilidade) e pontuação adicional ao projeto baseada na interação do público com ele e o destaque feito ao projeto com maior nota na avaliação global que inclui documentação, apresentação oral e visitas e comentários na rede social. Uma das turmas de Engenharia da Computação teve que divulgar seus trabalhos na rede social e as outras turmas mantiveram a dinâmica de semestres anteriores.

3.2 Processo e Coleta de Dados

No início do agosto os alunos foram informados que, em resposta a uma solicitação recorrente de maior divulgação de seus trabalhos semestrais, uma nova dinâmica seria adotada e foi aplicado um questionário em que eles deveriam escolher uma, dentre duas opções: (a) criar um website para o projeto ou (b) criar uma página em rede social para o projeto. De um total de 88 alunos matriculados nas turmas de Engenharia da Computação que poderiam participar do projeto, houve um total de 57 alunos respondentes, e desses, 43 escolheram a criação de página em uma rede social (cerca de 75%).

Após a definição do uso de uma rede social, neste caso, o Facebook, os alunos iniciaram seus projetos como tradicionalmente fazem e uma turma de 39 alunos iniciou, paralelamente, o processo de divulgação a partir da criação de uma página pública no Facebook para cada um os grupos. Os estudantes das outras turmas sabiam da dinâmica instituída na turma de teste (TT) e deveriam interagir com os projetos nas páginas criadas para divulgação.

Para dar continuidade à coleta de dados, foram disponibilizados novos questionários aos alunos da TT em que se desejava coletar informações sobre suas percepções em relação:

(i) Ao tempo investido com rede social sobre o projeto;

(ii) A divulgação das informações do projeto, publicamente, durante sua execução;

(iii) Aos mecanismos de pontuação para o projeto;

(iv) Ao aumento da motivação *versus* competição entre estudantes

Os questionários foram aplicados no final do mês de setembro de 2017, momento em que os estudantes finalizaram uma das etapas do projeto e precisavam fazer uma entrega parcial de documentos técnicos do projeto aos docentes. Uma nova aplicação foi feita no final do ano, momento em que há a entrega final de documentos e apresentação oral dos trabalhos para verificar se há alguma mudança na percepção dos alunos. Em ambos os instrumentos há espaço também para comentários gerais dos estudantes.

4 Análise dos Dados

Considerando que os dados foram coletados no meio do semestre letivo e nova coleta foi realizada em dezembro, apresentamos os resultados de ambas as coletas de dados, analisando-as comparativamente.

4.1 Sobre o Tempo de Dedicação

Os alunos que responderam a perguntas que solicitavam uma **estimativa do tempo dedicado à página do projeto (em horas por dia)** e **se achavam que esta atividade extra impactaria negativamente na parte técnica do trabalho**.

Em setembro, as respostas ao questionário apontaram, em linhas gerais, que o tempo dedicado à elaboração, configuração e manutenção das páginas dos projetos na rede social não teriam impacto sobre os resultados do projeto, pois *"[passam] grande parte do dia postando alguma coisa"* e essa atividade seria assimilada na rotina diária do grupo. Também comentaram que como *"dominamos o Face, fica fácil gerenciar a página"*.

Em média, os alunos afirmaram dedicar entre 30 minutos e 1 hora diária à página do projeto e, sobre o impacto negativo, em uma escala de 1 (nenhum), 2 (muito pouco), 3 (pouco), 4 (médio impacto) a 5 (alto impacto), <u>acreditavam que não haveria impacto</u> sobre os resultados, sendo que foram 35 respostas 1, 3 respostas 2 e 1 resposta 1.

Em dezembro, após terem finalizado seus projetos, o tempo de dedicação à página do projeto caiu pela metade e, mencionaram que se não tivessem criado a página poderiam ter se dedicado mais à parte técnica do projeto.

4.2 Sobre a Divulgação das Informações

Em uma pergunta aberta, eles foram questionados sobre a divulgação das informações do projeto e **que pontos positivos e negativos apontavam** neste item.

Neste item, surgiu uma divisão entre os estudantes, pois mostraram uma grande motivação pela divulgação de seus projetos e de imagens dos grupos durante seu processo de desenvolvimento. No entanto, em setembro havia um pequeno grupo (cerca de 5 alunos) que temiam pela possibilidade de alguém apropriar-se indevidamente da ideia de seus projetos, (este número subiu para 12 em dezembro) o que poderia gerar problemas futuros em caso de comercialização de algum produto resultante deles.

Por outro lado, a grande maioria (30 estudantes) vê nisso uma forma de mostrar a seus amigos e familiares um pouco do que fazem durante seu curso, o que demonstra envolvimento e certo grau de afetividade com o curso e com a instituição de ensino.

Na pesquisa feita em dezembro, apareceram sugestões de divulgação em outros meios, como blogs e web sites com restrição de acesso.

4.3 Sobre os Mecanismos de Pontuação

A pergunta foi feita em relação à forma de pontuação definida para diferenciar os projetos. O mecanismo escolhido para esta primeira edição foi a **contagem de "likes"** conseguidos nas postagens do grupo e a **quantidade de seguidores da página**.

Em setembro, os estudantes acreditavam que por serem critérios objetivos, os "likes" eram adequados, no entanto, na avaliação de dezembro, alguns estudantes comentaram que descobriram geradores de "likes" que podem falsear os resultados finais e sugeriram que em uma próxima edição sejam colocados desafios que permitam diferenciar um grupo de outro, colocando-os em "níveis" diferentes e sugeriram algum tipo de insígnia para diferenciar (de tempos em tempos) a colocação de cada um dos grupos em relação aos outros.

4.4 Sobre o Aumento da Motivação *vs* Competição

Em uma questão aberta, os alunos deveriam fazer um comentário geral sobre a nova dinâmica e informar o que estavam achando, até o momento, das modificações feitas no processo de desenvolvimento do projeto e se, na visão deles, notavam alguma mudança de comportamento dos integrantes dos outros grupos na forma de interagir com eles.

De forma geral, em setembro, as respostas foram positivas em relação à dinâmica porque *"sentem que há interesse [da coordenação e dos professores] por melhorar a qualidade da formação deles"* e que isso, na visão deles, é fator de motivação *"para fazer ótimos projetos"*.

No que se refere ao relacionamento entre os alunos de diferentes grupos, o que aparece nos comentários é um maior interesse do trabalho de uns pelos trabalhos dos outros, por terem mais informações e poderem buscar entender melhor o que os outros estão fazendo.

No entanto, a avaliação de dezembro trouxe alguns novos elementos que devem ser analisados mais detidamente. Apesar de terem gostado da nova dinâmica, de acharem interessante divulgar seus projetos (com restrições), a percepção da grande maioria dos estudantes é de que o ganho para o projeto não foi significativo e que acreditam que o processo deva sofrer modificações na próxima edição.

5 Conclusões

O principal objetivo deste trabalho é entender a percepção dos estudantes em relação à mudança provocada no processo de desenvolvimento de seus projetos semestrais com a inserção de elementos de jogos, mais precisamente, a partir da publicação das informações dos projetos em rede social, neste caso, o Facebook.

Considerando a aplicação de questionários em dois momentos distintos, podemos inferir que os impactos causados pela inserção de elementos de jogos são positivos, no sentido de estimular a divulgação dos projetos realizados, no entanto, esta divulgação, na percepção dos estudantes, não pode ser ampla e irrestrita.

Os mecanismos de pontuação, bem como a inserção de outros elementos motivadores e de novas formas de divulgação estão sendo discutidos e fazem parte de uma próxima etapa desta pesquisa.

Com os resultados até aqui obtidos, é possível concluir que o trabalho adicional é significativo aos alunos, principalmente, na segunda metade do semestre e que a competitividade entre as equipes continua sadia, mas é preciso analisar melhor os impactos sobre a motivação dos alunos no sentido de continuar mantendo atualizadas as informações sobre o projeto.

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Aligning the Route: the BPL method as a didactic resource in the students' perception of Production Engineering

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Abstract

Project-based learning PBL is an innovative pedagogical strategy that has been gaining more and more supporters in higher education. The PBL has as one of its premises to encourage the approach of the theory with the practice and the pro-activity of the student, who ceases to play the role of passive receiver of the information transmitted by the teacher to be the protagonist of the teaching-learning process. The Production Engineering course was a pioneer in the adoption of this active methodology, from the University of Brasília - UnB, with interested teachers and engaged in the proposal. However, although it is accepted and validated by teachers, it is important to constantly evaluate the contribution of this methodology to the student understanding in order to understand their real gains. The objective of this work is born to reach this premise: to understand the current perception of the students in order to improve the didactic resource in the teaching practice. Based on semi-structured interviews and analyzed from the point of view of content analysis through IRAMUTEC software, this study interviewed students of the UnB Production Engineering course, from the 3rd year, to evaluate the methodology used in the course. As a result, this research found strong contributions from the group regarding PBL's earnings: students cited the opportunity to experience the market, prepare for real work situations, and develop other socio-emotional skills. As challenges, a greater openness of the partner companies to offer their data, the greater use of the anchor disciplines as a support to the projects and the expectation of working better the conceptual issues related to the course.

Keywords: PBL Methodology, Assessment, Student Perspective.

Alinhando a Rota: o método BPL como recurso didático na percepção dos alunos de Engenharia de Produção

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Abstract

A aprendizagem baseada em projetos PBL é uma estratégia pedagógica inovadora que vem conquistando cada vez mais adeptos no ensino superior. O PBL tem como uma de suas premissas incentivar a aproximação da teoria com a prática e a pró-atividade do aluno, que deixa de exercer o papel de receptor passivo das informações transmitidas pelo professor para ser o protagonista do processo ensino-aprendizagem. O curso de Engenharia de Produção foi pioneiro na adoção dessa metodologia ativa, da Universidade de Brasília - UnB, com professores interessados e engajados na proposta. Contudo, apesar de aceito e validado pelos docentes, é importante avaliar constantemente a contribuição dessa metodologia no entendimento discente para conseguir entender seus reais ganhos. O objetivo desse trabalho nasce para atingir essa premissa: entender a atual percepção dos alunos no intuito de aprimorar cada vez mais o recurso didático na prática docente. Baseado em entrevistas semiestruturadas e analisado sob o ponto de vista da análise de conteúdo por meio do software IRAMUTEC, este estudo entrevistou estudantes do curso de Engenharia de Produção da UnB, a partir do 3º ano, para avaliar a metodologia utilizada no curso. Como resultado essa pesquisa encontrou fortes contribuições do grupo no que concerne aos ganhos do PBL: os discentes citaram a oportunidade de vivenciarem o mercado, se prepararem para situações reais de trabalho, bem como desenvolverem outras habilidades sócio emocionais. Como desafios, uma abertura maior das empresas parceiras no sentido de oferecem seus dados, a maior utilização das disciplinas âncoras como apoio aos projetos e a expectativa de se trabalhar melhor as questões conceituais ligadas ao curso.

Keywords: Metodologia PBL, Avaliação, Perspectiva Discente.

1 Introdução

Considerando seu importante papel em formar indivíduos éticos e preparados para desenvolverem o país em termos econômicos, culturais, políticos, sociais e ambientais, as Instituições de Ensino Superior estão repensando sua forma de ensino-aprendizagem na tentativa de acompanhar as mudanças conceituais e tecnológicas do mundo contemporâneo.

Competir com a alternativa de se estudar onde quiser e no tempo disponível, preceito preconizado pelo ensino à distância (Gonzalez, Pohlmann Filho e Borges, 2001; Belloni, 2002), ou até mesmo com a possibilidade da internacionalização do saber (Morosini, 2006; Lima & Contel,2011) que oferece intercâmbios e outras modalidades disponíveis, dificulta cada vez mais a sensibilização do aluno para a aprendizagem na sala de aula de forma presencial, principalmente mantendo-se o modelo de ensino tradicional e suas aulas de transmissão de conhecimento do professor-aluno.

Na perspectiva de atualizar essas práticas educacionais, a pedagogia progressista (Freire, 1987; Behrens, 2005) transformou-se e consolidou-se como uma abordagem inovadora, centrada nos alunos que descarta a uniformidade e a estandardização do conhecimento e defende que a diversidade do aprendiz deve ser reconhecida e promovida.

Sem subestimar, entretanto, a importância da literacia e da numeracia, os educadores progressivos atuais entendem que é possível atingir esses objetivos através da resolução de problemas práticos bem como atividades que despertem o interesse dos alunos (Canaleta *et al.* 2014), transcendendo as fronteiras entre as disciplinas e restaurando a experiência como forma de aprendizagem.

Atento às tecnologias educacionais com o objetivo de oferecer um ensino inovador e coerente com as necessidades dos alunos, o curso de Engenharia de Produção da Universidade de Brasília - UnB, oferta para o seu corpo discente uma forma de aprendizagem baseada em resolução de problemas ou *Problem Basead Learning* (PBL). A metodologia ativa, utilizada também em outros cursos de engenharia no país e no mundo, mostrou-se como um modelo que maximiza os pontos fortes do aluno na medida em que permite que ele se posicione sobre um tema ou problema no qual possui mais afinidade ou dúvida respeitando, sobretudo, suas necessidades. Além disso, como um dos maiores resultados, essa metodologia ativa apresentou um real convívio entre estudantes de engenharia de produção e professores, ampliando suas habilidades e competências, bem como as suas interações com o mundo (Gerhart & Melton, 2016; Kuimova, Burleigh & Trofimova, 2016; Terrón-López *et al.*, 2015; Vélez & Hernandez, 2016).

Contudo, apesar de aceita e difundida pelos docentes do curso de Engenharia de Produção da Universidade de Brasília é importante avaliar constantemente a contribuição dessa metodologia para entender seus reais ganhos. Têm-se então o problema dessa pesquisa: Os estudantes que vivenciam as técnicas do PBL estão satisfeitos com essa metodologia desenvolvida no curso de Engenharia de Produção da UnB? Baseado em entrevistas semiestruturadas e interpretado sob o ponto de vista da análise de conteúdo, este estudo considerou uma amostra dos estudantes do curso de Engenharia de Produção da UnB, a partir do 3º ano que já experimentaram essa prática docente, para avaliar a metodologia PBL utilizada no curso.

A justificativa desse trabalho estaria na possibilidade de corrigir possíveis erros de rota na condução da metodologia do curso e manter o seu padrão de qualidade e excelência, reconhecido nacionalmente por meio dos resultados positivos do Exame Nacional De Desempenho de Estudantes - ENADE.

O objetivo desse trabalho nasce, portanto, da necessidade de ouvir a percepção dos alunos do curso de Engenharia de Produção na perspectiva de que ele seria um dos principais atores interessados na melhoria contínua do curso . Inicialmente foram discutidos os conceitos do PBL no curso de Engenharia de Produção na UnB e a importância da avaliação como forma de aprimorar a técnica.

2 Referencial Teórico

2.1 Problem Based Learning no curso de Engenharia da Produção na UnB

As transformações da sociedade refletiram também na necessidade de modificar as formas tradicionais de ensinar, de aprimorar constantemente as práticas e os saberes docentes. De acordo com Silva *et. All* (2016) o profissional que ensina as disciplinas de Engenharia tem um treinamento basicamente técnico e, em geral por isso, dificilmente transmite seu conhecimento com didática. Entretanto, o curso de Engenharia de Produção da Universidade de Brasília (EPR/UnB) está desconstruindo essa premissa e ofertando egressos com habilidades socioemocionais desenvolvidas para o mercado de trabalho da capital federal.

O curso foi pioneiro na metodologia *Problem Based Learning* – PBL aplicando-a há mais de seis anos e, os resultados já podem ser observados. No último resultado divulgado pelo Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira – INEP, órgão governamental que avalia a qualidade dos cursos de graduação do ensino superior por meio do Exame Nacional de Desempenho dos Estudantes – ENADE, a nota do curso de EPR/UnB figurava como a segunda melhor do país. O sucesso está fortemente associado à metodologia ofertada aos alunos e, também, aos professores no papel de guias ativos da autoaprendizagem de grupos de estudantes em torno de problemas reais. Contudo, avaliar a adoção das metodologias de ensino ativas, sobretudo na percepção dos discentes, um dos protagonistas desse modelo de aprendizagem, torna-se fundamental para o processo de aprimoramento do método.

2.2 Importância da avaliação dos resultados de ensinoaprendizagem

Partindo da premissa do Sistema de Regulação e Avaliação Nacional, que determina a qualidade dos cursos, por meio Sistema Nacional de Avaliação da Educação Superior – Sinaes, observa-se três dimensões propostas pelo governo que devem ser sistematicamente seguidas para que o curso continue funcionando com boas notas: a avaliação das instituições, dos cursos e do desempenho dos estudantes.

Entretanto, entende-se que para além das regulações institucionais externas, a avaliação deve ser concebida como um instrumento que realmente contribui para a construção e o aperfeiçoamento do conhecimento e práticas de ensino aprendizagem nas Instituições de Ensino Superior. Nesse contexto ela assume dois objetivos fundamentais: um que realiza a verificação e a mensuração do aprendizado do aluno, apresentando quantitativamente seus resultados (Moretto, 2005) e outro que atende a exigência da própria formação do educando no seu sentido mais amplo, comprometido com uma educação emancipatória e cidadã (Luckesi, 1997).

Nessa perspectiva, torna-se fundamental oportunizar a opinião dos alunos acerca do ensino oferecido. Além de coletar subsídios para a melhoria concreta do curso, aluno ainda tem a oportunidade de refletir e problematizar sobre sua própria caminhada (Tamayo & Uriarte, 2016).

3 Metodologia

Trata-se de uma pesquisa exploratória, com abordagem Qualitativa e Quantitativa. A pesquisa foi realizada no Distrito Federal, no curso de Engenharia de Produção da Universidade de Brasília por meio de entrevistas semiestruturadas, no período de maio a junho de 2017. Os critérios de inclusão foram todos os alunos, a partir do 3º ano, que já tivessem participado de aulas com a metodologia PBL. O critério de exclusão abrangeu todos os alunos que não sinalizaram o ano que cursavam durante a entrevista. A coleta de dados foi realizada por um estudante do curso de Engenharia de Produção que gravou as entrevistas orientando os respondentes com os seguintes comandos: dizer o período que cursavam, o primeiro nome e responder à pergunta: "O que você acha do Curso de Engenharia de Produção ser baseado em PBL?". A amostra total foi de 11 entrevistas.

A Análise de Conteúdo subsidiou a interpretação dos dados do presente estudo. Segundo Cavalcante, Calixto & Pinheiro (2014) esse método é um conjunto de técnicas de pesquisa que permitem a descrição das mensagens e das atitudes atreladas ao contexto da enunciação, bem como realizar inferências sobre os dados coletados, de forma sistemática. A escolha deste método permitiu a compreensão das significações e as relações que se estabeleceram além das falas propriamente ditas.

Os dados coletados foram analisados pelo software IRAMUTEC que, de acordo com os estudos de Santos *et al.* (2017) é um recurso importante de apoio à pesquisa qualitativa que auxilia no processo de tratamento de dados, mas não substitui o papel central do pesquisador.

4 Resultados e Discussões

Além da análise qualitativa dos pesquisadores, também foram realizadas análises de Estatísticas do corpus do texto, Especificidades e Análise Fatorial Confirmatória e Estudo de Similitude com o software IRAMUTEC afim de sistematizar os dados qualitativos e conferir-lhes a força de técnicas estatísticas padronizadas.

Acerca das Estatísticas do corpus do texto tiveram 11 entrevistas reportadas, 1020 ocorrências de palavras no total do corpus textual, sendo dessas, 271 palavras diferentes e, 139 que foram mencionadas apenas uma vez, mas que para esse estudo também foram consideradas visto que a maioria das respostas se deu de forma sucinta e resumida.

O gráfico 1 representa o logaritmo desses dados revelando principalmente que no corpo textual existem muitas palavras que se repetem pouco e poucas palavras que se repetem muito.

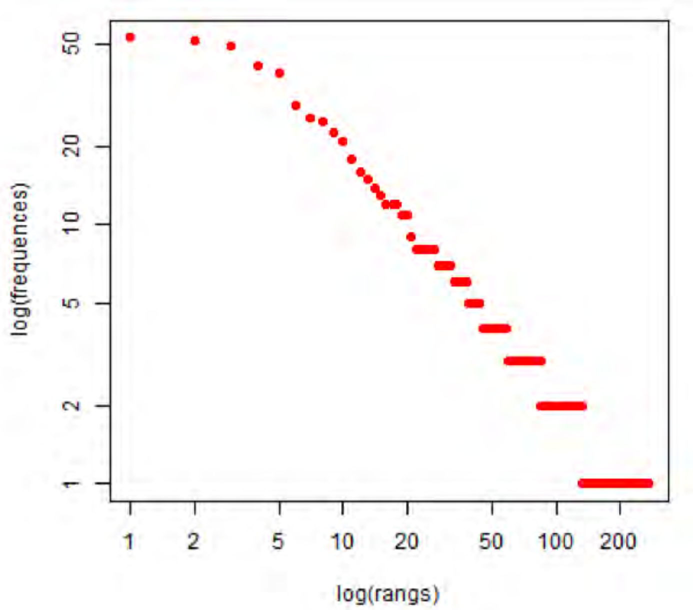

Gráfico 1 – Estatísticas do Corpus textual (Fonte: IRAMUTEC)

A interpretação das Especificidades e Análise Fatorial Confirmatória apresentaram que a população entrevistada se dividiu em clusters nos quadrantes, conforme mostra o Gráfico 2, da seguinte forma: Indivíduos 5, 3 e 7 no primeiro quadrante superior, indivíduo 1 e 9 no segundo quadrante superior, indivíduos 6, 4 e 11 no primeiro quadrante inferior e indivíduos 2, 8 e 10 no segundo quadrante inferior.

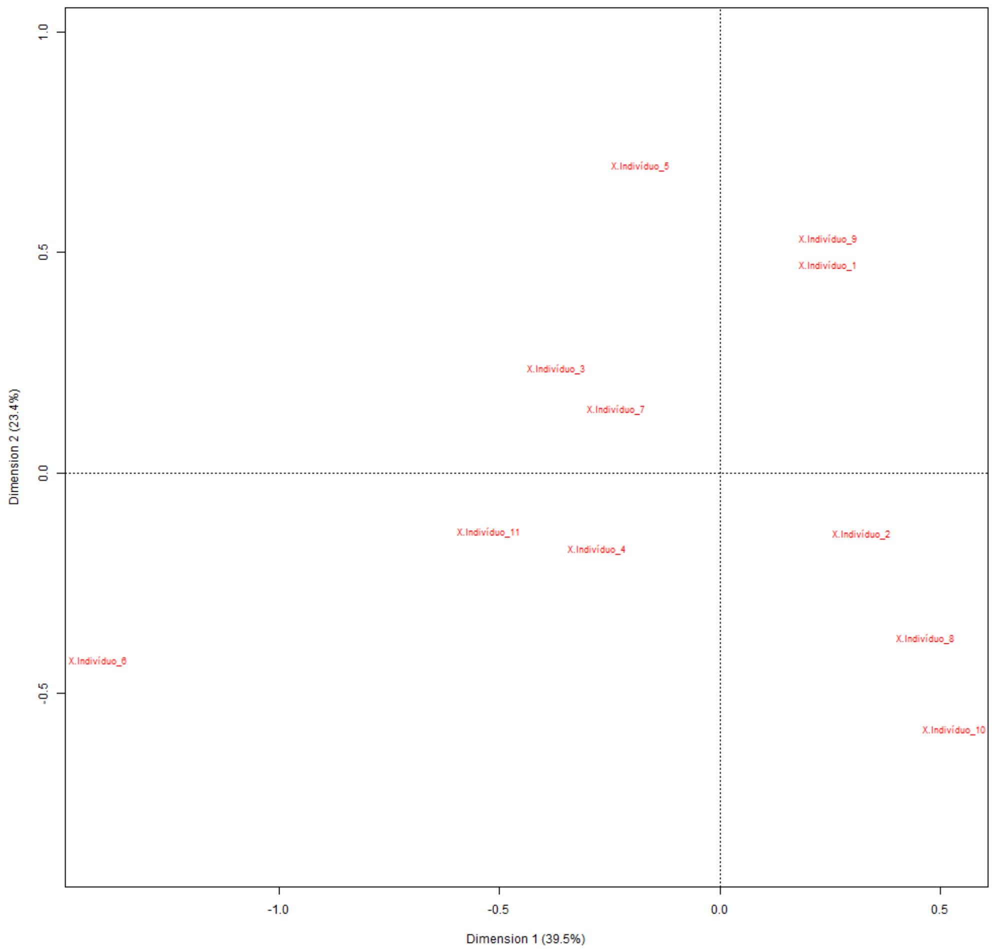

Gráfico 2 - Especificidades e Análise Fatorial Confirmatória (AFC) - Fonte: IRAMUTEC

Os clusters representam a proximidade do tema dos discursos dos entrevistados. Quanto mais próximos mais parecido o assunto tratado. De fato, pode-se observar as seguintes premissas dos respondentes de acordo com o Quadro 1.

Quadro 1 - Especificidades e Análise Fatorial Confirmatória –Premissas por Clusters - Fonte: Autor, com informações do IRAMUTEC.

	Indivíduos	Premissas
Cluster 1	5, 3 e 7	Implementação da teoria na prática, Possibilidade de trabalhar com as empresas, Trabalho em equipe, Desenvolvimento de habilidades diversas.
Cluster 2	1 e 9	Preparado para situações reais no trabalho, Resolução de problemas reais
Cluster 3	6, 4 e 11	Soluções superficiais e inventadas, empresas não passam os dados para os alunos, alunos inventam dados
Cluster 4	2, 8 e 10	Maior utilização das disciplinas âncoras para conseguir resolver os problemas da maneira mais adequada e não da maneira mais fácil. Trabalhar mais cálculo no curso, O curso não oferece bases conceituais para quem não quer trabalhar com consultoria.

Em relação ao grau de similitude entre as palavras, ou seja, a capacidade de inferir a estrutura da construção do texto e dos temas de relativa importância e como eles se conectam, tem-se o gráfico 3 que destaca as seguintes palavras: “achar”, “muito” e “gente”. Como pode-se observar, a palavra “achar” é a mais importante e foi dita inúmeras vezes na entrevista. Isso se confirma em relação à pergunta dessa pesquisa visto que se trata da opinião dos alunos em relação a metodologia PBL. Essa palavra aparece relacionada a: “legal, problema, bom, bem, diferencial, equipe, projeto” o que evidencia a opinião favorável do grupo acerca da pergunta orientadora.

Já as palavras que seguem o grupo “muito” são: “solução, ancorar, disciplina” e estão ligadas ao cluster 4 que deseja solução para a melhoria das disciplinas âncoras no curso de Engenharia. No grupo de “gente” percebe-se a coletividade de forma relevante, atreladas a palavras como: “prático, empresa, dados, visão” sugerindo a construção do pensamento dos entrevistados que também elogiam o PBL como metodologia.

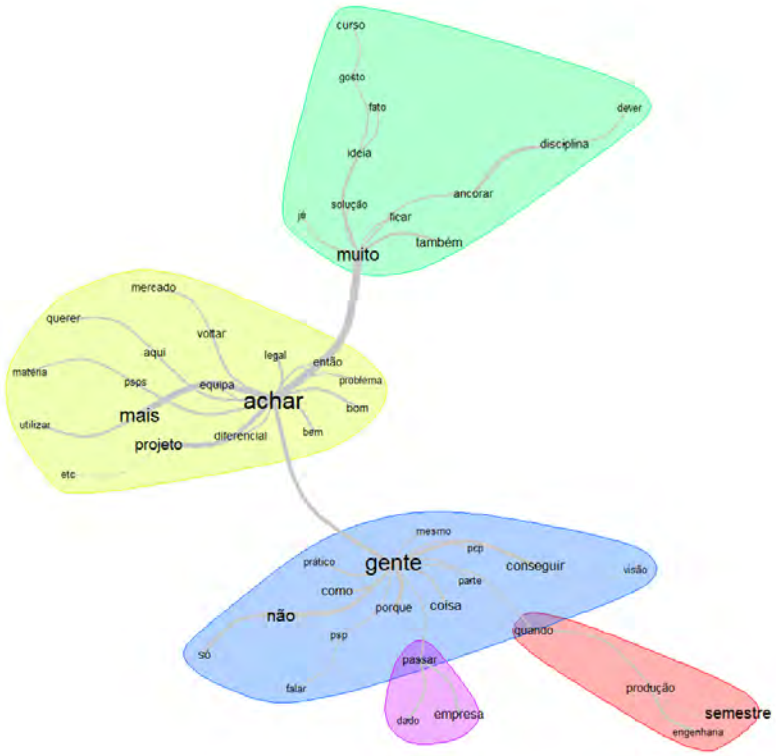

Gráfico 3 - Similaridade entre as palavras - Fonte: IRAMUTEC

5 Conclusões

Participaram desse estudo 11 entrevistados que cursam a partir do 3º ano da graduação em Engenharia de Produção da Universidade de Brasília. Como considerações finais tem-se que os respondentes foram demasiadamente sucintos em suas respostas, adicionaram diversas gírias e apresentaram vocabulário pobre, o que dificultou o processamento dos dados pelo software IRAMUTEC. Isso ficou evidenciado no gráfico de Similaridade que apresentou as palavras “acho, gente, muito” como raízes de suas construções do pensamento. Entretanto pode-se considerar, com esses dados, que o senso de coletividade representado na palavra “gente” foi preservado, e concluir que os alunos realmente pensaram na coletividade do programa e das experiências para se posicionarem, bem como o caráter opinativo da pesquisa, nessa ocasião representada pelo verbo “achar”.

Como resultado da análise de Especificidades e AFC nota-se que nos quadrantes 1 e 2 aparecem indivíduos que fizeram mais comentários positivos em relação a metodologia PBL e, nos quadrantes 3 e 4 aqueles que relataram problemas ou sugestões para aprimoramento do método e do curso.

Como principais elogios à metodologia PBL e sua aplicação no curso de EPR/UnB tem-se a implementação da teoria na prática com a possibilidade de trabalhar com as empresas. O trabalho em equipe e o desenvolvimento de habilidades diversas também foi colocado como resultado positivo do método. Como pontos a serem melhorados, na perspectiva de alinhar a rota do curso tem-se abertura maior das empresas parceiras no sentido de oferecem seus dados com a intenção de acabar com trabalhos baseados em dados "inventados" pelos alunos.

Outro ponto levantado foi a maior utilização das disciplinas âncoras como apoio dos projetos, na expectativa de se trabalhar melhor as questões conceituais ligadas ao curso. Em relação à disciplina de cálculo foi relatado que o curso faz poucas menções à essa área específica e que por isso não se sentem preparados para trabalharem fora da área de consultoria. Entretanto reconhecem que privilegiar a área de consultoria aumenta a inserção dos profissionais de Engenharia de Produção no mercado de trabalho de Brasília.

Nesse sentido esse estudo respondeu ao seu problema de pesquisa bem como alcançou o objetivo de ouvir os estudantes para alinhar a rota do curso.

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Active learning methods in the teaching of interdisciplinary themes for Engineering

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Abstract

This article seeks to present results from the application of active learning methods in the teaching of interdisciplinary themes for Engineering programs in the UnB Gama campus, which focus in environmental effects and are applicable in any engineering program. The active methodology enables the students to solve problems and develop solutions to transform reality. The methods have been used from 2010 to 2017 in the Environment and Engineering course offered to freshmen students. The exercise contributes to the inclusion of environmental requirements as variables in the productive process. The proposal is grounded in the lifecycle approach, integrating supply chains. The study object is a product or residue to be tracked. The starting point is the identification of environmental impacts that can be traced back to any points the object's lifecycle, from the extraction of raw materials to the end of life. Then a plan for bibliography survey, data gathering and processing, analysis, production of results, presentation in class and extension of results to the community, by means of presentations in local schools. The work, conducted in teams, presents the opportunity of collaboration and contributes to the sense of community of the engineering students. During this process they identify the social actors and their responsibilities in the supply chain, the environmental requirements of productive processes in regulations, standards and good practices, the main issues found in seeking compliance and possible solutions. Professors and students evaluate the methods and results from the project, and the evaluation is taken into account in the next iteration of the method. The main result is the opportunity afforded for students to interact with the reality outside of the academy, which are thus better prepared for the profession of Engineering.

Keywords: Environmental Management; Engineering Education; Life Cycle Assessment, Project Approaches.

Métodos de Aprendizagem Ativa de Temas Transversais em Engenharia

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Resumo

O objetivo desse artigo é apresentar os resultados da aplicação de métodos de aprendizagem ativa no ensino de temas transversais para cursos de Engenharia do campus UnB Gama, com foco em meio ambiente e que podem ser replicados em outros cursos. Os métodos têm sido aplicados de 2010 a 2017, na disciplina Engenharia e Ambiente, ofertada para alunos de primeiro semestre. O exercício metodológico contribui para o aprendizado da inclusão de requisitos ambientais como variável nos processos produtivos. A proposta se fundamenta no pensamento do ciclo de vida e a cadeia produtiva de diversos produtos. Um projeto de pesquisa aplicada é realizado em cada edição da disciplina, com um produto ou resíduo a ser rastreado. O ponto inicial é a identificação de um impacto ambiental, que pode ser vinculado a qualquer ponto do ciclo de vida do produto, desde a captação de recursos naturais até a destinação final. A seguir é realizado o planejamento do estudo, pesquisa bibliográfica, coleta e tabulação de dados, análises, elaboração de resultados, apresentação aos pares em sala de aula. Os resultados são apresentados também à comunidade, em escolas locais de ensino fundamental e médio. O projeto é delineado e executado por equipes, proporcionando a oportunidade de trabalhar de forma colaborativa e contribuindo com a formação cidadã dos estudantes de engenharia. Neste projeto são identificados os principais atores sociais e as respectivas responsabilidades nas cadeias produtivas, os requisitos ambientais dos processos produtivos, sejam legais, normativos ou boas práticas institucionalizadas, as dificuldades encontradas para o cumprimento desses requisitos e as possíveis soluções. Os métodos e os resultados do projeto são avaliados por professores e estudantes e contribuem para o aperfeiçoamento da edição posterior, servindo como oportunidade da interação com a realidade fora da academia e que farão parte do cotidiano do engenheiro.

Keywords: Gestão ambiental; Educação em Engenharia; Avaliação do Ciclo de Vida; Project Approaches.

1 Cenário e Contexto

Para compreender o conjunto de métodos de aprendizagem ativa no ensino de temas transversais é importante identificar o cenário de aceleração de mudanças causadas no planeta pelas ações humanas com impactos negativos por meio de alterações químicas e física no solo, corpos hídricos e atmosfera com consequências negativas sobre a vida. Essas mudanças ocorrem, principalmente em função dos processos de geração de energia, pelas obras de construção de infraestrutura e edificações, produção agropecuária, transportes, produção de bens e serviços, enfim, todas as "obras de engenharia" para sustentar uma população que já ultrapassa mais de sete bilhões de pessoas.

Historicamente os engenheiros brasileiros são formados por escolas de engenharia com pedagogia tradicional. É perceptível que as universidades precisam mudar os paradigmas de ensino e os métodos utilizados. Essa mudança pode atender a demandas por ações social e ambientalmente responsáveis e mais sustentáveis, e, cada vez mais, por soluções que diminuam os impactos negativos causados pelo modo de vida e produção capitalista atual. O desafio na engenharia é desenvolver processos produtivos de menor impacto ambiental e soluções que contribuam para aumentar a resiliência dos ecossistemas construídos, face aos desafios como mudanças climáticas, má gestão de água, resíduos, transportes, de uma população urbana cada vez maior.

O ideal é formar engenheiros que consigam ultrapassar as fronteiras do processo produtivo tradicional, "entre portões de fábricas" e desenvolvam visão sistêmica, com responsabilidade ambiental e social. Eles podem ser capazes de estender a sua responsabilidade na cadeia produtiva de fornecedores e nos resíduos gerados pelas atividades humanas, e ainda, que dominem ferramentas de planejamento e gestão, em níveis fora da organização, em todo o campo organizacional, que considerem como variáveis importantes do processo produtivo o controle de impactos negativos desde a sociedade local à mundial.

O relatório do Programa das Nações Unidas para o Meio Ambiente, Panorama Ambiental Global: ambiente para o futuro que nós queremos (GEO 5), pode ser utilizado como uma ferramenta de apoio essencial na formação de engenheiros que sejam capazes de analisar os problemas ambientais globais (UNEP, 2012).

Para que as escolas de engenharia sejam capazes de alcançar essas metas é preciso que adotem efetivamente uma abordagem inovadora em métodos aprendizagem ativa que possam contribuir com esta formação.

A metodologia é uma forma de encaminhar o aluno para a formação profissional (Richartz, 2015). Mas de uma forma diferente da escola tecnicista de reprodução. Nessa nova roupagem o aluno é estimulado a criticar, a desenvolver o raciocínio lógico e crítico. O estudante deve ser estimulado a problematizar, refletir, escolher, criar, intervir e transformar o "fazer" do trabalho pedagógico por meio da organização do ensino-aprendizagem a partir da pesquisa e a "práxis" com a aplicação e reflexão do teórico. As principais habilidades desenvolvidas no aluno são autonomia, criatividade, responsabilidade e iniciativa, além das competências que preveem o conhecimento específico da área pedagógica, como visão holística dos problemas, trabalho ético e em grupo, de forma inter e transdisciplinar (Richartz, 2015).

Os cursos de engenharia aeroespacial, automotiva, eletrônica, energia e software, do campus UnB Gama, foram concebidos de forma que o estudante receba uma formação básica de engenharia antes de fazerem a opção de curso. Nessa formação é ofertada a alunos de primeiro semestre a disciplina "Engenharia e Ambiente". Nesta disciplina, desde 2010 têm sido utilizadas metodologias ativas, proporcionando aos estudantes a oportunidade de exercitar conceitos de ecologia, responsabilidade ambiental e social em todo o ciclo de vida dos produtos, da extração de recursos no ambiente até o seu fim de vida, ou reinserção em alguma cadeia produtiva, considerando o pensamento sistêmico e pensamento de ciclo de vida.

O cenário trabalhado no projeto de pesquisa aplicada e extensão desenvolvido na disciplina Engenharia e Ambiente tem sido, preferencialmente o entorno do campus, a Região Administrativa do Gama, principalmente na fase de uso e descarte dos produtos. Diversas cadeias produtivas têm sido utilizadas como tema para a realização desse projeto de ação contínua em metodologia de aprendizagem ativa no ensino de temas transversais para engenharia, com foco em "meio ambiente" e divulgados em eventos na área de Ensino em Engenharia, Ambiente e Sociedade (FERRARI et al. 2011a, e FERRARI et al. 2017).

O tema gestão de resíduos sólidos tem sido recorrente devido à complexidade do problema social e dos diversos conhecimentos requeridos. A divulgação dos resultados tem sido feita em fóruns dedicados à Gestão de Resíduos Sólidos (FERRARI et al. 2011) e à Avaliação de Ciclo de Vida (FERRARI et al., 2013).

Outras iniciativas, em parceria com professores da disciplina têm sido desenvolvidas na utilização de métodos de aprendizagem ativa como atividades de disciplinas e em projetos de Extensão.

Projetos de iniciação científica têm sido desenvolvidos com o objetivo de produzir material didático para a disciplina, tais como simuladores informatizados e uma plataforma informatizada participativa para gestão de resíduos sólidos, o Observatório de Resíduos, com os resultados divulgados em Congresso de Iniciação Científica de (ARAÚJO, 2016); (DADAMOS, 2016), (MOREIRA, 2016). O Observatório de Resíduos está disponível na internet em www.observatorioderesiduos.unb.br e tem sido utilizado como uma ferramenta didática da disciplina para aprendizado e compartilhamento de resultados. Além dessa ferramenta, também foi desenvolvido por alunos de Engenharia de Software, como parte das atividades das disciplinas "Métodos de Desenvolvimento de Software" e "Gestão de Processos de Projetos", um aplicativo para sistemas operacionais Android, com banco de dados integrado ao Observatório de Resíduos, para que o usuário possa identificar e georreferenciar os resíduos sólidos disposto incorretamente e também os Pontos de Entrega de Resíduos (PEV).

Este projeto visa contribuir para a formação de engenheiros sensibilizados para a importância a inclusão das variáveis ambientais e sociais nos processos produtivos, que sejam capazes de conceber e atuar além dos limites dos portões das fábricas. Que esta contribuição seja tanto para a construção de seu próprio capital reputacional, assim como para proporcionar a oportunidade de alcançar um importante nicho de mercado, considerando as diretrizes e premissas assumidas mundialmente pela Organização das Nações Unidas para o meio Ambiente (UNEP, 2012; UNEP 2016).

Este artigo apresenta o panorama geral dos métodos utilizados de 2010 a 2017 na disciplina Engenharia e Ambiente, demonstrando a evolução da metodologia, em função dos resultados obtidos em cada edição dos erros identificados, das avaliações realizadas pelos estudantes e pelos professores parceiros e das observações e inferências pela equipe de professores e estudantes parceiros, que desenvolvem projetos complementares de pesquisa e extensão.

2 Metodologia

Em todas as edições da disciplina, antes da realização do projeto de pesquisa aplicada, há um período de estudo do conteúdo teórico com os conceitos fundamentais, construído de maneira participativa, por meio do estudo de "textos sementes". Esses textos são elaborados pela docente, e contém a estrutura básica das "Notas de Aula", com identificação dos objetivos a serem alcançados em cada aula e sugestões de leitura. Nas últimas duas edições, foi organizada a estrutura de conteúdos do curso, foi elaborada a versão 1.0 de um projeto de construção colaborativa de conteúdos complementares, no sítio web do projeto Wikiversidade. A estrutura de avaliação dos alunos na disciplina tem sido mantida ao longo de todas as edições, com 65% dos pontos concedidos atribuídos à avaliação dos fundamentos teóricos e 35% ao trabalho prático.

Os fatores que são importantes considerar na definição das metodologias de ensino é que as salas de aula ainda possuem uma infraestrutura com o formato tradicional e o sistema de ensino que ainda predomina na maioria das escolas de ensino médio e fundamental e da própria universidade para tratar o conteúdo teórico das disciplinas são aulas expositivas. Observações feitas em sala de aula permitem afirmar que os estudantes possuem muitos fatores de dispersão da atenção e foco, apresentam dificuldade de concentração, leitura, estudo, redação, principalmente para temas que não consideram como "área core da engenharia". É importante ressaltar também que, devido ao fato de que a Faculdade UnB Gama foi criada no Projeto REUNI de descentralização dos campi, foram concebidas salas com capacidade para 130 alunos para as disciplinas de primeiro semestre.

Durante o período de estudo teórico os estudantes têm a oportunidade de se organizarem em equipes, para apresentação de alguns tópicos do conteúdo teórico e que servem para testes das parcerias e preparação para o projeto final.

No semestre 1/2014, na oitava edição do método de tema transversais e com a percepção de heterogeneidade das turmas a ser executado um diagnóstico do perfil social dos estudantes. Esse diagnóstico considera uma série de fatores, tais como sexo, idade, local de origem, mecanismo de entrada na universidade, o nível de conhecimentos anteriores relatado, o semestre que está cursando na universidade, o número de vezes que já cursou a disciplina e o nível de desempenho, tipo de escola em que cursou o ensino médio (pública ou particular), nível de escolaridade dos pais, bem como a forma de ingresso na universidade (Avaliação Seriada, Vestibular ou SISU). A coleta de dados passou a ser padronizada, tornando possível reuni-los para uma análise geral e tornando-os comparáveis por semestre. Registra-se que desde o começo houve interesse de estudantes egressos da disciplina pelo tema e pela metodologia, tornando-se monitores, contribuindo na coleta e análise dos dados, no tratamento estatístico e se tornando-se parceiros da pesquisa e coautores.

A definição do tema das duas primeiras edições, a gestão de resíduos sólidos urbanos na Região Administrativa do Gama, com foco em Resíduos de construção (RC), Resíduos de Serviços de Saúde (RSS), papéis, eletroeletrônicos, óleos e gorduras, lâmpadas fluorescentes considerou o volume e os riscos ambientais representados por esses resíduos. Nessas edições o perímetro urbano do Gama foi dividido em quatro áreas de atuação (Setores Leste, Oeste, Norte e Sul). A coleta de dados consistiu em observações de campo, visita ao canteiro de obras na construção de edificações, visitas a farmácias e postos de saúde para verificar o recolhimento de RSS, visitas a bares e restaurantes para abordar a coleta de óleo, visita à Associação de Catadores e às lojas que vendiam eletroeletrônicos.

Na terceira edição da aplicação da metodologia ativa os aparelhos celulares foram considerados como um tema importante, destacando-se como resíduo eletroeletrônico relevante e de grande interesse pelos estudantes, passando a ser objeto de pesquisa por quatro semestres. Nessas edições foi feita a pesquisa junto a fabricantes, comerciantes e usuários de celulares.

Os passos metodológicos para realização do projeto pelas equipes incluem: (a) definição de um tema, considerando assuntos de relevância no momento, contexto político, técnico, social e importância local e nacional; (b) elaboração de um Termo de Referência contendo os princípios norteadores, objetivos, métodos, produtos e cronograma de entrega; (c) organização dos estudantes em equipes de cinco a sete participantes com definição de um líder responsável pela interlocução com a professora, supervisão, monitoramento, avaliação da equipe e entrega dos produtos intermediários e finais; (d) identificação de uma escola de ensino médio e fundamental para apresentação dos resultados (a partir da edição do segundo semestre de 2017); (e) planejamento, coleta, tabulação, análise e emissão do relatório final; (f) elaboração de uma vídeo aula – opcional até o primeiro semestre de 2015, compulsório a partir daí; (g) avaliação do desempenho dos estudantes, por observação direta, avaliação nas entregas e, ou apresentações parciais, realizadas nos pontos de controle e final; (h) avaliação do método pelos estudantes; (i) análise dos resultados para emissão da edição posterior.

3 Resultados

O projeto de pesquisa aplicada e extensão na disciplina Engenharia e Ambiente foi iniciado no segundo semestre de 2010, em caráter experimental, como teste do método. A escolha de um tema considerado relevante pelos estudantes, em um cenário que a Política Nacional de Resíduos Sólidos (PNRS) estava em foco, tendo sido instituída pela Lei 12.305 e publicada em 2 de agosto de 2010 (BRASIL, 2010), e um grupo de alunos motivados para a realização da proposta podem ter sido forças motrizes fundamentais para o sucesso da primeira edição e continuidade do projeto.

Os resultados alcançados ao longo de todas as edições da realização do projeto serão abordados segundo o período integral de aplicação, de forma que proporcione ao leitor uma visão sistêmica, ressaltando as particularidades de algumas edições. O primeiro tópico tratado é caracterização do perfil dos estudantes, o número de estudantes alcançados, os temas tratados e justificativa, a avaliação dos métodos pelos estudantes, as análises e avaliações e pela equipe de professores e as considerações sobre a evolução do método.

3.1 Caracterização dos estudantes

A caracterização do perfil dos estudantes feita na primeira e segunda edições do método (Ferrari et al., 2011) e (Ferrari et al., 2011a) demonstrou que a origem dos estudantes estava distribuída entre 21 regiões administrativas do Distrito Federal e ainda as cidades de Luziânia e Novo Gama, ambas localizadas no estado de Goiás.

Uma caracterização mais completa do perfil dos estudantes passou a ser realizada na quinta edição do método, de 2014 a 2017. Nesse período foi identificada uma distribuição de 20% de mulheres e 80% de homens nas turmas, com desvio padrão de 16,7. A classificação por idade demonstrou que 50% dos alunos estava em uma faixa etária entre 16 e 18 anos, 32% entre 18 e 20 anos, 10% entre 20 e 22 anos e 8% acima de 22 anos e desvio padrão de 18,3.

O ensino médio foi cursado integralmente em escola particular por 58% dos estudantes, em escola pública por 37%, sendo que 5% dos estudantes cursaram escola particular e, ou pública, com desvio padrão de 19,6. Houve entrada por meio do Programa de Avaliação Seriada por parte de 13%, pelo SISU 41% e por Vestibular 46%.

O nível de escolaridade das mães e pais variou de ensino fundamental a pós-graduação. Para as mães, 53,5% possuem nível superior completo e, ou pós-graduação e 32, 7% possuem nível médio completo ou superior incompleto. O desvio padrão foi de 19.02. Para os pais, 51, 1% possuem nível superior completo e, ou pós-graduação, 30, 7% possuem curso médio completo ou superior incompleto, com desvio padrão de 16,4.

O semestre letivo em que os estudantes estão cursando quando fizeram a disciplina Engenharia e Ambiente variou de primeiro semestre (74%), segundo e terceiro (12%), quarto e quinto (9%), sexto a oitavo (3%) e nono ou superior (2%). O desvio padrão foi de 19.4. O número de vezes que já cursou a disciplina varia desde a primeira vez (76%), segunda vez (22%) e terceira vez (2%), com um desvio padrão de 18,3.

Toda essa caracterização foi importante para confirmar a heterogeneidade da turma e a dificuldade de se definir metodologias de ensino que atendam às demandas e características de todos os estudantes. O método de pesquisa aplicada e extensão utiliza essa heterogeneidade a favor do aprendizado, uma vez que os estudantes têm a oportunidade de trabalhar em equipe e trocar experiências, em um cenário real, com problemas reais e atores reais, onde as variáveis não são controladas.

3.2 Temas e observações gerais

Em todas as edições do projeto de pesquisa aplicada a proposta da metodologia foi ampliar a visão dos estudantes para além das fronteiras dos processos produtivos, criando oportunidade para que eles visualizassem todo o ciclo de vida do produto, desde o berço até o túmulo, ou até o novo berço, com a identificação dos aspectos ambientais, dos requisitos ambientais e das responsabilidades. Além disso, foi demonstrada a importância do papel dos engenheiros como tomadores de decisão, da importância de conhecerem requisitos legais, normativos e de boas práticas institucionais.

Os resultados das duas primeiras edições foram publicados no 3º Fórum Internacional de Resíduos Sólidos (Ferrari et al., 2011) e no 33º Congresso Brasileiro de Educação em Engenharia (Ferrari et al., 2011a). As dificuldades das organizações possuem de quantificar resíduos e demonstrar resultados refletem na dificuldade de coleta de dados pelos estudantes, que foram expostos a ambientes desfavoráveis, em que a frustração com a falta de dados obtidos levou a várias reflexões e hipóteses levantadas e discutidas em sala de aula. Na primeira edição foi levantada a demanda pelos entrevistados sobre palestras sobre o tema de gestão de resíduos em canteiros de obras e sobre a gestão de resíduos de saúde, tendo sido realizados esses eventos na segunda edição.

Nessas edições também foram identificadas possibilidades de parceria com proprietários bares e restaurantes, para doação dos resíduos de óleo para o projeto de Extensão da FGA, BIOGAMA, foram levantados os possíveis pontos para recolhimento de resíduos de óleos de fritura para transformação em sabão e, ou Biodiesel na Usina da FGA.

Da terceira à sexta edição foram rastreadas as cadeias produtivas de eletroeletrônicos, com foco em cadeias de celulares. Os fluxogramas do ciclo de vida desde o berço até o berço foram levantados, com identificação de entradas de insumos e saídas de resíduos, efluentes e emissões. Os atores e responsabilidades, bem como mecanismos de governança foram identificados. Uma carta institucional de apresentação das equipes de estudantes foi fornecida. Os principais fabricantes foram contatados pelos estudantes, para coletas de dados quantitativos, por meio de Serviços de Atendimento ao Consumidor, dos mecanismos de contato no próprio sítio institucional por correspondência eletrônica, por redes sociais das organizações. As Associações de Classe também foram consultadas, e uma grande dificuldade de na disponibilização de dados que permita a utilização da metodologia de ACV para ensino foi encontrada e utilizada como objeto de discussão dos estudantes. O Arranjo Produtivo Local da cadeia de Resíduos de eletroeletrônico, os atores e mecanismos para Logística Reversa da cadeia de celulares foram identificados. Os resultados foram divulgados na V Conferência Internacional de Avaliação de Ciclo de Vida, realizado em Mendoza, Argentina (FERRARI et al., 2013).

Na sétima edição os estudantes pediram para que o tema fosse deixado livre e eles passaram a pesquisar diversas cadeias produtivas. O ciclo de vida do produto foi descrito por meio da elaboração de fluxogramas e identificação de entradas e saídas de insumos, resíduos, emissões e efluentes. O critério para seleção de produtos a ser utilizado deveria ser a identificação de empresas que comunicassem em seus sítios institucionais a implantação de Sistemas de Gestão Ambiental, certificados ou não, atendimento aos Indicadores Ethos, publicação de Relatórios de Sustentabilidade de acordo com o Global Reporting Initiative (GRI), critérios de compra responsáveis. Os fabricantes foram abordados de formas diversas, telefone, SAC, site, redes sociais, correspondência eletrônica, tendo os estudantes enfrentado a mesma dificuldade na obtenção de respostas das instituições consultadas.

A 12ª edição foi realizada após o acidente da Mineradora Samarco, que aconteceu em novembro de 2015. As proporções e dimensões sociais e ambientais do acidente criaram um cenário favorável a uma grande discussão sobre a Avaliação do Ciclo de Vida dos produtos cuja matéria prima é minério de ferro, levando à decisão de se estudar as cadeias produtivas de siderurgia com a identificação dos requisitos ambientais dos processos produtivos e as respectivas responsabilidades pelo Ciclo de Vida dos produtos. Da mesma forma, uma carta de apresentação institucional foi fornecida às equipes, empresas foram identificadas e contatadas por todas as formas de comunicação disponíveis e comunicadas à sociedade, com baixíssima taxa de resposta. A elaboração de um fluxograma do processo produtivo desde o berço a berço e a tentativa de coleta de dados para a Avaliação de Ciclo de Vida foi realizada.

Na 13ª edição foi retomada a discussão sobre resíduos sujeitos à logística, a falta de avanços e os entraves para efetivação dos Acordos Setoriais da Logística Reversa. Os critérios para identificação dos produtos e fabricantes, bem como os procedimentos para coleta de e análise dos dados foram os mesmos das versões anteriores. As cadeias produtivas dos seguintes produtos foram pesquisadas: agulhas de tatuagem, celulares, embalagens de agrotóxicos, embalagens tetrapack, garrafas de vidro, isopor para embalagem, lâmpadas fluorescentes, óleos automotivos, pneus, garrafas PET, pilhas. Comerciantes locais e geradores de resíduos na região administrativa do Gama foram contatados. Vídeo aulas foram produzidas e palestras foram realizadas nas escolas locais, no Gama.

Os resultados alcançados na 14ª edição, realizada no primeiro semestre de 2017 foram publicados no VIII Encontro Nacional de Pesquisa e Pós Graduação e Ambiente e Sociedade (ENANPPAS 2017) e abordaram as cadeias de resíduos de construção, Resíduos de Serviço de Saúde, principalmente medicamentos e embalagens. Vídeo aulas foram produzidas e palestras foram realizadas nas escolas locais, no Gama (FERRARI et al., 2017).

As pesquisas e coletas de dados junto a fabricantes, comerciantes e população local em todas as edições sempre foram informativas, abordando o papel do entrevistado no compartilhamento de responsabilidade do ciclo de vida dos produtos, os requisitos legais e os impactos ambientais resultantes de todas as ações. O feedback imediato para os entrevistados, seja sobre informação de requisitos legais ou boas práticas para a gestão dos resíduos.

A falta de efetivação de um instrumento proposto pela PNRS (BRASIL, 2010) e pelo seu Decreto Regulamentador (BRASIL, 2010a), o Sistema Informatizado de Informações sobre Resíduos Sólidos (SINIR), bem como a falta de efetividade dos sistemas de Logística Reversa, a ausência de um banco de dados brasileiro com dados e informações que possibilite a disponibilização dos dados para projetos de pesquisa e ensino foi, em parte, frustrante para o alcance total dos resultados do projeto, em parte uma ótima oportunidade de aprendizado e discussões sobre a efetividade e eficácia das políticas públicas e seus impactos sobre a sociedade.

Os temas tratados nas edições do método e a quantidade de alunos que cursaram a disciplina estão sumarizados na tabela 1.

Tabela 1 – Distribuição de temas do projeto de pesquisa aplicada de 2010 a 2017

Semestre/ Edição	**Estudantes**	**Tema**
2010/2 (1)	240	Resíduos de Construção (RC), óleo de fritura, Serviço de Saúde (RSS), eletroeletrônicos

2011/1 (2)	131	Resíduos de Construção (RC), óleo de fritura, Serviço de Saúde (RSS), eletroeletrônicos
2011/2 (3)	131	Celulares (Avaliação de Ciclo de Vida – ACV)
2012/1 (4)	110	Celulares (ACV)
2012/2 (5)	110	Celulares (ACV)
2013/1 (6)	48	Celulares (ACV)
2013/2 (7)	50	Produto de qualquer cadeia produtiva (ACV)
2014/1 (8)	87	Produto de qualquer cadeia produtiva (ACV)
2014/2 (9)	102	Produto de qualquer cadeia produtiva (ACV)
2015/1 (10)	109	Produto de qualquer cadeia produtiva (ACV)
2015/2 (11)	75	Produto de qualquer cadeia produtiva (ACV)
2016/1 (12)	121	Cadeia produtiva de metais ferrosos (mineração, siderurgia, metalurgia)
2016/2 (13)	81	Resíduos sujeitos à logística reversa (LR)
2017/1 (14)	56	RC, RSS com ênfase em medicamentos, Resíduos de embalagens na RA Gama
2017/2 (15)	48	Embalagens de vidro, óleos automotivos, pneus, pilhas e baterias, eletrônicos, lâmpadas

3.3 Avaliação do método pelos estudantes

Desde a primeira edição o método e os resultados alcançados têm sido avaliados pelos estudantes e os resultados utilizados para planejar e executar a edição posterior do método. Porém, a partir da segunda edição de 2014 a padronização do método de avaliação possibilitou a reunião das amostras e a análise de todo o período.

Uma proporção de 94% dos alunos afirmou que o objetivo da disciplina estava claro, e os restantes 6% que não, com um desvio padrão de 18,8. O objetivo do estudo de caso, no entanto, foi considerado claro para 58% dos estudantes e não claro para os demais 42%, com um desvio padrão de 19.

O primeiro item avaliado sobre o estudo de caso, o Termo de referência, foi considerado claro para 38% dos estudantes, compreensíveis com dificuldade, para 57% e difíceis de compreender para 5%. O desvio padrão da amostra foi 19.8. Uma proporção de 44% dos estudantes considerou que o estudo de caso exigiu "mais do que foi passado em sala de aula", 55% consideraram que o que foi exigido condiz com o que foi passado e 5% consideraram que foi exigido menos do que passado em sala de aula. O desvio padrão foi de 19,1.

O estudo de caso foi considerado importante e um fator de contribuição para o aprendizado por 98% dos estudantes, assim como o estudo do tema para sua formação profissional.

3.4 Avaliação do desempenho dos estudantes

Ao longo de todo o período de aplicação do método observou-se que o fato de não haver uma resposta exata ou uma única solução para as para as perguntas foi um fator de incômodo para os estudantes, assim como o fato de que muitos fatores não são controláveis. Outro fator de que provocou sempre incômodo e frustração foi o fato de que as empresas não forneciam as respostas claras e objetivas para as perguntas e, muitas vezes sequer respondiam às questões. O fato de não haver dados quantitativos para os cálculos necessários aos estudos de avaliação de ciclo de vida também foi outro fator de frustração.

Um fator que permanece ao longo de todo o período foi o comportamento de tentar fazer o trabalho com um prazo muito curto, próximo ao prazo final e a dificuldade de refazer, corrigindo os erros. Como o método determina vários pontos de controle, as equipes precisavam produzir sucessivas versões a serem corrigidas e aperfeiçoadas. Verificou-se um comportamento diferente do líder em relação a todos os demais participantes, devido ao fato de ter um cronograma para cumprir e ser responsáveis pela entrega do produto. De maneira geral, em todas as edições os líderes relatam "excelente oportunidade" para aprender sobre gestão de pessoas, dificuldade de lidar com pessoas sem comprometimento com a qualidade e prazos e ter que arcar com as lacunas deixadas por pessoas que abandonam a equipe e desistem da disciplina.

4 Conclusão

A experiência de realizar um projeto de pesquisa aplicada e extensão com interação da comunidade local tem sido positiva. As dificuldades enfrentadas pelos alunos na concepção da proposta, desde a identificação do problema, à elaboração da hipótese, coleta, sistematização e análise de dados foram consideradas importantes para fortalecimento da capacidade de aprendizado e desenvolvimento de habilidade de trabalhar em equipes interdisciplinares.

Os principais aprendizados da metodologia para os alunos foram a importância de ter a oportunidade de vivenciar problemas ambientais e sociais complexos em um cenário real, com variáveis não controladas, sem um gabarito para respostas, com a interação com atores reais. As frustrações a que os alunos foram submetidos geraram importantes contribuições.

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Adoption of Active Methodology at the Project Management Advanced course for engineers at University of Brasília, UnB.

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Abstract

The adoption of agile methods in project management has grown considerably, bringing positive results to projects in the short term. The Advanced Project Management course is offered for the Production Engineering course at the University of Brasília, providing students with project management knowledge from the perspective of two approaches: traditional and agile, and also emphasizes how aspects of quality, term, risk, scope, and cost can be worked to ensure project success. The discipline works with active methodology (Project Based Learning - PBL), where two projects are developed, one that adopts the traditional methodology and another that adopts agile. Agile has adopted SCRUM as the methodology for project development. In order to provide students with knowledge about SCRUM, a dynamic called SCRUMIA adapted from Wangenheim & Borgatto (2013) was applied, where students learned the concepts doing in practice. From the total of 27 students, 6 teams were trained to deliver a site of the Production Engineering course and used the SCRUM as an agile method for its development. The objective of this study was to understand students' perceptions of a new discipline executed via PBL. To achieve this goal, 16 interviews were carried out, analyzed through content analysis with Iramuteq. The results show that the intention to reflect on both types of methodologies was achieved and that it surpassed the students' expectations. As a legacy, an event was held in the auditorium of the Faculty of Technology, developed through a traditional methodology aimed at presenting the academic community with topics related to project methodologies, publicizing the site that was developed, reporting on their experiences with project methodologies and offering access to the content worked. The results were measured through a questionnaire, ensuring that students were satisfied. The event was able to involve 274 students who watched the results of the teams.

Keywords: Active Learning; Project Based Learning, Agile Methodology, Traditional Methodology.

Adoção de Metodologia Ativa na disciplina de Gerenciamento Avançado de Projetos para engenheiros da Universidade de Brasília, UnB.

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Abstract

A adoção dos métodos ágeis em gerenciamento de projetos tem crescido consideravelmente, trazendo resultados positivos aos projetos em curto prazo. A disciplina de Gerenciamento de Projetos Avançados é oferecida para o curso de Engenharia de Produção da Universidade de Brasília, fornecendo aos alunos conhecimentos de gestão de projetos sob o ponto de vista de duas abordagens: tradicional e ágil, e também enfatiza como os aspectos de qualidade, prazo, risco, escopo e custo podem ser trabalhados para se garantir o sucesso dos projetos. A disciplina trabalha com metodologia ativa (Aprendizagem baseada em projetos – PBL), onde são desenvolvidos dois projetos, um que adota a metodologia tradicional e outro que adota o ágil. O ágil adotou o SCRUM como a metodologia para o desenvolvimento dos projetos. Para proporcionar um conhecimento aos alunos sobre o SCRUM foi aplicado uma dinâmica denominada SCRUMIA adaptada de Wangenheim & Borgatto (2013), onde os alunos aprenderam os conceitos fazendo na prática. Do total de 27 alunos, formaram-se 6 equipes que trabalharam para entregar um site do curso de Engenharia de Produção e utilizaram o SCRUM como método ágil para seu desenvolvimento. O objetivo deste estudo foi compreender as percepções dos alunos sobre uma nova disciplina executada via PBL. Para alcançar este objetivo foram realizadas 16 entrevistas, analisadas via análise de conteúdo com o Iramuteq. Os resultados revelam que o intuito de reflexão sobre os dois tipos de metodologias foi alcançado e que superou as expectativas dos alunos. Como legado, foi realizado um evento no auditório da Faculdade de Tecnologia, desenvolvido por meio da metodologia tradicional visando apresentar a comunidade acadêmica temas relacionados às metodologias de projetos, divulgar o site que foi desenvolvido, relatando suas experiências com as metodologias de projetos e oferecer a acesso aos conteúdos trabalhados. Os resultados foram mensurados via questionário, assegurando que os alunos ficaram satisfeitos. O evento conseguiu envolver 274 discentes que assistiram aos resultados das equipes.

Palavras-chave: Project Based Learning; Metodologia ágil; Metodologia tradicional

1 Introdução

O dinamismo do mercado tem feito com que as organizações busquem práticas inovadoras e que tragam resultados efetivos em seus projetos. Como resultado dessa demanda diversas iniciativas para a adoção de metodologias ágeis são empreendidas nessas corporações com vistas a se tornarem mais dinâmicas, favorecendo assim a rápida mudança de direção caso haja uma demanda de mercado.

Visando atender as demandas de mercado por profissionais que tenham conhecimento em projetos, a Universidade de Brasília utiliza sete disciplinas de Projetos de Sistemas de Produção (PSPs) como a espinha dorsal do curso de Engenharia de Produção, do quarto ao décimo semestre do curso. As disciplinas de PSPs tem como intuito desenvolver no aluno competências transversais, tais como liderança, gerenciamento, proatividade, além das competências técnicas adquiridas ao longo do curso. Essas disciplinas utilizam como abordagem de ensino o Project Based Learning (PBL). O método PBL (*Project Based Learning*), traduzido como Aprendizado Baseado em Projetos, é uma estratégia pedagógica/didática centrada no estudante. Esse método é relacionado às teorias construtivistas, em que, devido a necessidade de um enfoque sistêmico e amplo, o conhecimento é tratado como algo não absoluto, ou seja, o estudante tem o poder, junto aos seus professores, de construir uma percepção global sobre os assuntos (Brandão, Lessandrini, & Lima, 1998). Os Projetos de Sistemas de Produção, apesar de serem um importante passo na formação do profissional, deixam ainda uma lacuna no que tange ao aprendizado efetivo em Gestão de Projetos. A introdução da disciplina Gestão de Projetos Avançados (GPA) na grade curricular do curso de graduação em Engenharia de Produção da

Universidade de Brasília tem como principal motivador preencher essa lacuna observada. Na disciplina de Gestão de Projetos Avançados são tratados os dois métodos de gestão mais utilizados na atualidade, o método tradicional, também conhecido como cascata, e os métodos ágeis. Visando explorar cada etapa e proporcionar uma experiência de imersão para os alunos também foi escolhido o método de ensino Project Based Learning (PBL). Dessa forma, os alunos são desafiados a desenvolver dois projetos durante o semestre, onde cada um é gerenciado de acordo com uma metodologia.

Durante o primeiro semestre de 2017 os discentes desenvolveram um projeto de criação de um *website* para o curso de Engenharia de Produção da UnB, o qual foi executado e gerenciado a luz do que preconizam os métodos ágeis e, para tal iniciativa, foi escolhido o Scrum como método ágil. O outro projeto desenvolvido pelos alunos foi um evento, para este último foram seguidos os ritos da metodologia tradicional com o apoio do Guia PMBOK 5ª Edição (Project Management Institute, 2013). Assim o objetivo desta disciplina foi compreender as percepções dos alunos sobre uma nova disciplina executada via PBL. Para alcançar este objetivo foram realizadas 16 entrevistas para análise do conteúdo.

2 Referencial Teórico

2.1 Project Based Learning (PBL)

O Project Based Learning (PBL) é uma abordagem de ensino projetada para engajar os alunos na investigação de problemas reais. Nesse modelo os estudantes buscam soluções de problemas não triviais debatendo ideias, fazendo previsões, desenvolvendo planos e/ou experimentos, coletando e analisando dados, comunicando suas conclusões a outros alunos, levantando novas questões e criando artefatos (Blumenfeld et al., 1991).

Blumenfeld *et al.*, (1991), afirmam ainda que existem dois componentes fundamentais em projetos: eles exigem uma pergunta que serve para organizar e dirigir atividades; e essas atividades resultam em artefatos ou produtos que culminam em um produto final que remete a pergunta inicial. Citam que projetos são incontestavelmente diferentes das atividades convencionais que são desenhadas para ajudar estudantes no aprendizado na ausência de uma questão direcionadora. Nesse sentido essa se torna a abordagem ideal para o ensino de metodologias de gestão de projetos, levando em consideração que projetos são elaborados sempre para responder a alguma questão ou solucionar algum problema.

2.2 Metodologia Tradicional de Gerenciamento de Projetos

A metodologia tradicional de gerenciamento de projetos data da metade do século XX. Princípios estabelecidos nos anos 50 descrevem que métodos e procedimentos devem ser aplicados a todos os projetos de uma forma uniforme (Špundak, 2014). Esta implementação uniforme deve garantir robusteza e aplicabilidade a uma enorme gama de projetos, desde os simples e pequenos projetos, até os grandes e mais complexos (Špundak, 2014). Os tradicionalistas defendem um planejamento extensivo, processos codificados e reutilização rigorosa para tornar o desenvolvimento uma atividade eficiente e previsível que amadurece gradualmente rumo à perfeição (Barry Boehm, [s.d.]). Projetos gerenciados de acordo com a abordagem tradicional estão focados na entrega do produto dentro do orçamento e do prazo estimado, preocupam-se mais em estar em conformidade com o planejado do que com entrega de valor ao cliente (Wysocki, 2014). Esse tipo de abordagem de gerenciamento de projetos é baseada em processos lineares ou incrementais (Wysocki, 2014). Uma abordagem linear busca entregar o produto completo ao final do projeto, como exemplo demonstrado na Figura 1.

Figura 10 - Metodologia tradicional - abordagem linear

Fonte: Wysocki (2014)

No entanto para que seja eficaz a utilização da metodologia tradicional é necessário que os requisitos e objetivos do projeto estejam claros e bem definidos. Nesse sentido, e levando também em consideração a robustez deste modelo de gestão, este tipo de abordagem se torna avesso a quaisquer mudanças (Wysocki, 2014). Esse tipo de abordagem, orientada sob aspectos de controles de processo, se torna subótima devido ao dinamismo dos ambientes de projeto atuais (Collyer, Warren, Hemsley, & Stevens, 2010).

Todas as objeções à abordagem tradicional de gerenciamento de projetos, juntamente com os pedidos crescentes de inovações contínuas que afetaram todas as indústrias e com as tendências de redução de custos, resultaram no surgimento de novas abordagens de gerenciamento de projetos, estas novas abordagens são comumente chamadas de métodos ágeis (Špundak, 2014).

2.3 Metodologia Ágil de Gerenciamento de Projetos

Devido a rápida evolução tecnológica e também do mercado, os modelos tradicionais de gestão começaram a perder espaço na indústria. A partir da década de 90 emerge então um novo modelo de gestão baseado no modelo lean, proposto na década de 50 na indústria automotiva (Middleton & Joyce, 2012), a abordagem lean tem como foco a eliminação do "lixo" do projeto, ou seja, daquilo que não gera valor para o cliente (Ohno, [s.d.]). Esta abordagem fornece os fundamentos sobre os quais estão estabelecidas as metodologias ágeis de desenvolvimento de software (Poppendieck, Poppendieck, & Wesley, 2003).

Enquanto a metodologia tradicional tem o foco no plano, as metodologias ágeis tem o foco nas mudanças (Wysocki, 2014) e na satisfação do cliente por meio da entrega de valor (Alahyari, Svensson, & Gorschek, 2017). A inevitabilidade do desvio nos planos do projeto, sugere que a solução não está em planos iniciais mais sofisticados, mas em metodologias que podem facilitar ações para resolver desvios. No ambiente de projetos de TI, essa necessidade de melhorar o processo de planejamento levou cada vez mais as empresas passarem a utilizar um processo que gira em torno de várias iterações através do ciclo de desenvolvimento em oposição a um processo tradicional de planejamento (Serrador & Pinto, 2015). A Figura 2 demonstra o modelo iterativo.

Figura 11 - Metodologias ágeis - modelo iterativo

Fonte: Wysocki, (2014)

Em contraste à metodologia tradicional os métodos ágeis são desenhados para utilizar a mínima documentação possível, facilitando assim a flexibilidade do projeto. Atualmente o modelo de gestão ágil mais utilizado mundialmente é o Scrum.

2.3.1 Scrum

O Scrum é um framework ágil de desenvolvimento e gestão de projetos, utilizado para o desenvolvimento de produtos complexos imersos em ambientes complexos, tem sua base no empirismo e utiliza uma abordagem iterativa e incremental para entregar valor com frequência (Sabbagh, 2014).

O Scrum é centrado no trabalho em equipe, melhoria da comunicação e na cooperação do time, no entanto não para assegurar o sucesso do projeto esta metodologia também estabelece uma série de regras e práticas (Bissi, 2007). Esse framework estabelece três grandes grupos: cerimônias (Sprint, Sprint Planning, Daiy Meeting, Sprint Review e Sprint Retrospective), artefatos (Product Backlog, Sprint Backlog e radiadores de informação) e pessoas (Product Owner, Scrum Master e Time de execuação).

Por se tratar do método mais difundido e utilizado mundialmente esse foi o método escolhido para aplicação na disciplina de Gestão de Projetos Avançados.

3 Métodos

Esta pesquisa é do tipo exploratória por meio estudo de caso com abordagem qualitativa. O objeto de estudo foi a disciplina de Gestão de Projetos Avançados, ministrada no curso de Engenharia de Produção da Universidade de Brasília-DF-Brasil.

Foram analisados os resultados da aplicação dessa nova disciplina no favorecimento da ampliação do conhecimento dos alunos da Engenharia de Produção na área de Gestão de Projetos. Para tanto, foi utilizada a estratégia de estudo de caso, evidenciando o desenvolvimento da disciplina e seus resultados.

Foram entrevistados 16 alunos e os resultados foram analisados com o programa Iramuteq. Quando se possui uma amostra pequena de textos, o Iramuteq solicita que ao menos 70% dos segmentos sejam aproveitados. Após realizado os cálculos de segmentos, se descobriu que de 85 segmentos dos 16 entrevistados, foi aproveitado 81,18%, sendo válida a análise.

A análise estatística dos dados foi feita por análise multivariada qualitativa, que permite uma compreensão de inter-relação de múltiplas variáveis. O programa utilizado foi o *Iramuteq*.

4 Desenvolvimento da disciplina

A disciplina Gestão de Projetos Avançados está baseada em duas metodologias de gestão aplicadas em diferentes projetos com objetivo de proporcionar aos alunos uma vivência real no desenvolvimento de projetos. Dessa forma, visando nivelar o conhecimento da turma na disciplina em questão, é necessário que as metodologias de Gestão de Projetos tenham seus conceitos clarificados para toda a turma. Para que os alunos consigam formar uma opinião crítica e fazer uma análise mais apurada acerca de cada um dos métodos aplicados, as aulas são ministradas de forma intercalada, abordando a cada encontro uma metodologia diferente. A disciplina foi estruturada com vistas a sempre conciliar as fases de ambos projetos de forma que os estudantes possam vivenciar a mesma fase do projeto sob a ótica de duas metodologias distintas em um curto intervalo de tempo. As primeiras aulas da disciplina oferecem uma visão geral das duas metodologias. O modelo tradicional é baseado nos conceitos apresentados no Guia PMBOK 5ª Edição (Project Management Institute, 2013), o qual fornece uma referência a nível de conhecimento e práticas de gerenciamento constituindo um padrão mundial aceito inclusive pela ANSI, onde são demonstrados todas as boas práticas contidas no material de referência, expondo todos os grupos de processo desde Iniciação até o encerramento, passando pelos grupos de processo de planejamento, execução e monitoramento, e controle. Conceitos básicos também são apontados e diferenciações importantes são externadas, como a diferença básica entre requisitos de um produto e de um projeto. O modelo cascata de gestão é caracterizado por fornecer planos muito bem definidos e documentação extensa e muito elaborada, no entanto, não necessariamente todos os processos precisam ser realizados, para otimizar o tempo da disciplina e dar foco ao que realmente seria relevante para o projeto. Dessa forma, foram mapeados quais processos eram relevantes ao projeto trabalhado em sala de aula e chegou-se a um plano de gerenciamento de projeto para ser utilizado como referência. Portanto, além de melhor aproveitar o tempo das aulas, outro ponto importante foi exposto, os alunos compreenderam que para cada projeto existe um nível de detalhamento específico necessário e que o Guia fornece uma orientação ao gerente, mas não o obriga a detalhar planos de todas as áreas de conhecimento elencadas no PMBOK. Para o método tradicional, na fase inicial a turma é dividida em grupos, onde cada grupo é responsável por gerar os artefatos preconizados no Guia PMBOK, tais como Estrutura Analítica do Projeto (EAP), que define os pacotes de trabalho a serem entregues e também todos os documentos de planejamento do projeto que será desenvolvido. Após a aprovação do projeto, os grupos são divididos ao qual um grupo é responsável pelo processo de integração e os demais assumem os pacotes de trabalho definidos na EAP, tendo um gerente para cada grupo, responsável pelas entregas e monitoramento do andamento das entregas de seus integrantes.

Assim como na metodologia tradicional, os primeiros encontros na metodologia ágil visam elucidar a forma de trabalho desses métodos. Para tanto, as aulas abrangem desde a história do surgimento dessas metodologias até os diversos *frameworks* de mercado utilizados na atualidade. Para o projeto ágil, o framework ágil escolhido para ser aplicado foi o Scrum, dessa forma também é demonstrada a composição desse método, com seus papéis (*Product Owner, Scrum Master* e Time de desenvolvimento), artefatos (backlog do produto, backlog da Sprint, histórias de usuário e radiadores de informação) e cerimônias (Sprint, reunião de planejamento da Sprint, reunião diária, reunião de revisão da *Sprint* e reunião de retrospectiva da Sprint).

As metodologias ágeis, ao contrário das tradicionais, são caracterizadas por não possuírem uma documentação abrangente, no entanto, para a disciplina, seguindo o proposto por Felipe Santos, em seu trabalho de graduação "Proposta de estrutura para implementação de metodologias ágeis para gerenciamento de projeto na disciplina de Projeto de Sistemas de Produção 5 da Universidade de Brasília" (Santos, 2016), foram inseridos dois documentos para o processo de Iniciação e Planejamento, o primeiro é o *Business Case Canvas* e o segundo o *Project Model Canvas*. A cada encontro é solicitado que os alunos apresentem parte da documentação necessária para compor cada projeto, assim o trabalho de elaboração dos planos é diluído no decorrer da disciplina e possibilitando que os professores possam *dar feedbacks* constantes acerca do que está sendo produzido pelos estudantes.

Com intuito de aperfeiçoar o conhecimento teórico sobre métodos ágeis ministrado em sala, é aplicada uma dinâmica chamada SCRUMIA, que possibilita uma vivência inicial do Scrum antes de efetivamente aplicar o framework no projeto. O SCRUMIA é um jogo manual que utiliza papel e canetas utilizado para reforçar e ensinar a aplicação do Scrum em cursos de computação em complemento as aulas teóricas (Von Wangenheim, Savi, & Borgatto, 2013). O SCRUMIA comtempla o planejamento e a execução de uma iteração em um projeto hipotético aplicando o Scrum (Von Wangenheim *et al.*, 2013). O jogo é desenvolvido por times compostos por até 06 participantes, cada qual exercendo um papel da referida metodologia. No jogo os times são equipes de trabalho de uma empresa e responsáveis pelo atendimento de 03 diferentes clientes. Cada cliente possui um conjunto de necessidades, divididas em histórias de usuário, onde cada uma apresenta um retorno em valor e satisfação para o cliente. Os times devem atender as necessidades dos clientes de forma que ao final da iteração consigam gerar o máximo de valor e satisfação possível aos clientes. O time vencedor é aquele que consegue a maior pontuação com a combinação desses dois fatores. Para que seja possível alcançar o objetivo do projeto da dinâmica os times passam por todas as cerimônias propostas no framework, estimam os pontos de esforço das histórias, realizam a reunião de planejamento, as reuniões diárias e ao final procedem com a reunião de revisão (Figura 3).

Figura 12 - Aplicação da dinâmica SCRUMIA na turma de Gestão de Projetos Avançados do segundo semestre de 2017

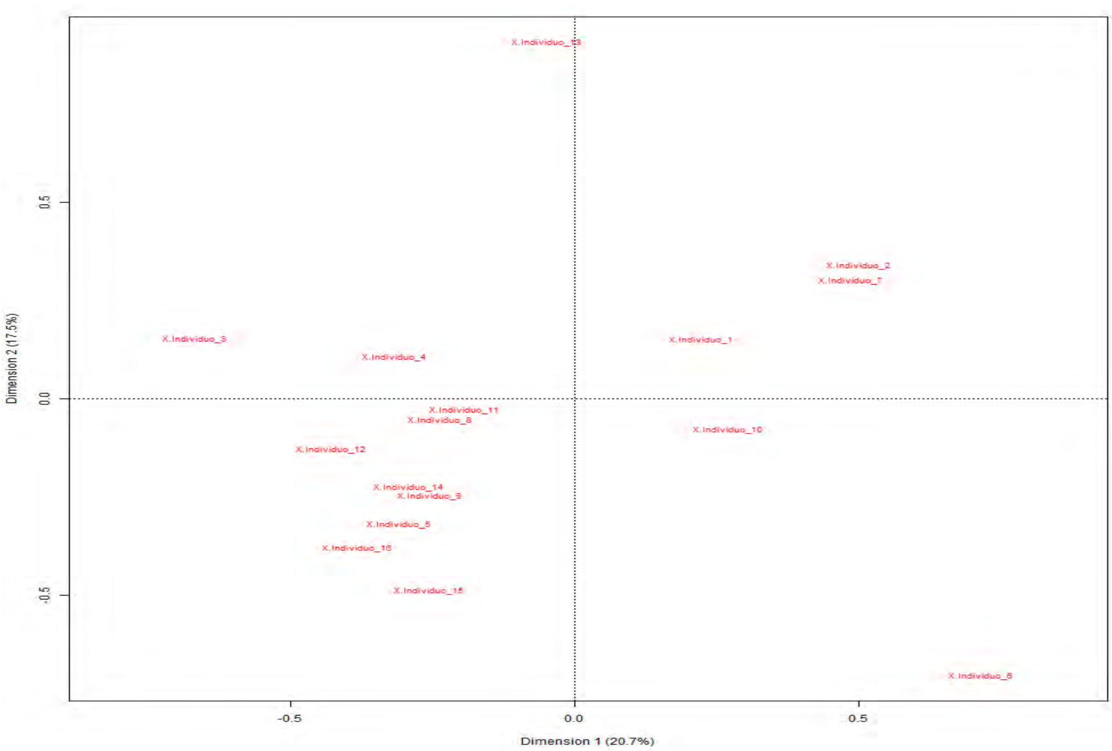
Após a aplicação da dinâmica e planejamento do projeto entende-se que os alunos já possuem o conhecimento mínimo necessário para o desenvolvimento do projeto, assim dá-se início ao período de desenvolvimento dos projetos. A cada aula é solicitado que os alunos apresentem o andamento dos projetos, sempre intercalando as metodologias e, consequentemente os projetos, ou seja, em uma aula se trata do acompanhamento do projeto regido pela metodologia tradicional e na seguinte do projeto regido pelo método ágil. Dessa forma é possível um acompanhamento próximo dos alunos e feedback constante acerca do desempenho e da aplicação das práticas de ambas as metodologias.

Ao final do semestre letivo os projetos são apresentados a comunidade da Faculdade e Tecnologia, coletadas as lições aprendidas a respeito do desenvolvimento dos projetos que comporão uma base de conhecimento para os projetos futuros. Como parte final da disciplina é aplicado um questionário para os alunos com intuito de coletar sua percepção sobre as metodologias de gestão, avaliar pontos fortes e fracos de cada uma e analisar a evolução do crescimento do conhecimento dos alunos sobre cada método de gestão. Os resultados coletados no primeiro semestre de 2017 são apresentados na seção 5.

5 Resultados

Foram entrevistados 16 indivíduos participantes da disciplina de Gestão de Projetos Avançados para saber suas percepções sobre a disciplina e sobre o tipo de método: Tradicional e Ágil. Três perguntas foram respondidas: três pontos positivos e negativos no método tradicional, três pontos positivos e negativos no método ágil, e impressões sobre a disciplina. Entre as formas ativas que mais foram contabilizadas no texto dos 16 participantes estão projeto (32) estabelecendo o princípio fundamental da disciplina, execução (21) sugerindo o caráter aplicado da disciplina e palavras como documento (15) e escopo (14) aparecem marcadas e associadas ao tempo curto para realização do solicitado, como entregas e documentação, sendo aconselhado pelos entrevistados uma melhor definição do escopo ao princípio da disciplina. A palavra planejamento (14), aparece como principal fator de comparação entre a metodologia tradicional ou ágil. A palavra muito (22) aparece associada a superação da disciplina na expectativa dos alunos e a palavra professor (10) aparece como fator muito importante na orientação e *feedback*. Para compreender o discurso dos entrevistados, foi realizada uma análise fatorial confirmatória para aproximar os indivíduos segundo o tipo de discurso empregado, quanto mais afastados do centro, mais os discursos tendem a ser negativos (Figura 4). A Matriz é dividida em duas dimensões que situam o discurso quanto sua carga negativa (opiniões desfavoráveis) e carga positiva (opiniões favoráveis).

Figura 4 – Análise fatorial dos indivíduos e seus discursos



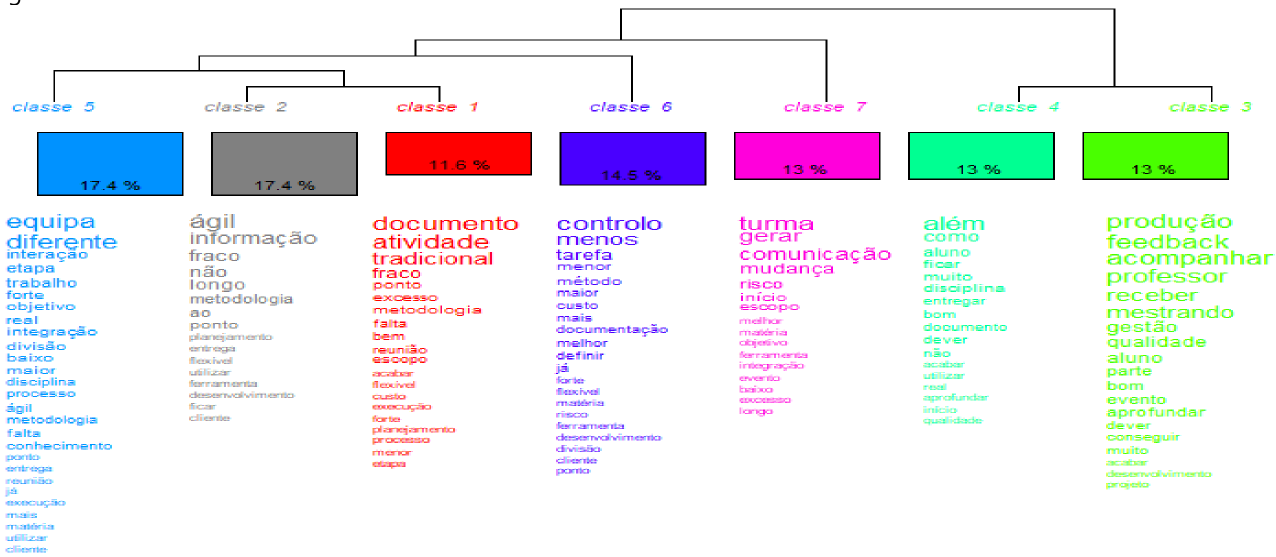
Fonte: própria. Extraído do Iramuteq

Pode-se perceber na figura 4, que o indivíduo 13 é o que possui o discurso mais afastado dos demais. Seguido do indivíduo 6 e 10, que não se aproximam de nenhum núcleo. Ao revisar as entrevistas, pode-se perceber que o indivíduo 6 possui um discurso isolado onde se coloca com uma postura negativa colocando seu foco na falta de organização da disciplina, provavelmente causada pela mudança de escopo, normal quando se trabalha com projetos, principalmente ágeis. O indivíduo 13 expressa também expressa a necessidade de maior organização, mas tem um discurso muito positivo em relação ao evento e o site realizado pelos alunos. Por último o indivíduo 10, que trata de explicar que o uso de ferramentas e tutores foi fundamental, embora faça uma crítica a necessidade de mais recursos (financeiros e estruturais) da universidade e engajamento da turma.

O cluster formado pelos indivíduos 1, 2 e 7 deixam claro sua satisfação pela disciplina, mas que devia ser explicada do nível de envolvimento que ia demandar, pois parte dos alunos trabalha e a disciplina foi muito laboriosa. O cluster formado pelos indivíduos 11, 8, 12, 14, 9, 5, 16 e 15, explicam que gostaram da disciplina e que seu modelo deveria ser adotado por outros PSP´s. Alguns alunos manifestaram que devia mudar de nome. O último núcleo formado pelos indivíduos 3 e 4, reconhecem o valor da disciplina, mas preferem menos documentação e mais prática, com definições mais claras por parte dos professores.

Pode-se observar a perspectiva do discurso do indivíduo. Porém ao centrar-se na análise das palavras dos entrevistados pode-se perceber a existência de 7 classes diferentes de discurso (Figura 5). No conjunto mais distante, pode-se observar a presença de duas classes (4 e 3), marcada por palavras como "além", "como" ,"aluno", "ficar", que se relacionam as opiniões de exceder as expectativas em relação ao conteúdo e ao trabalho, uma preocupação real com outros alunos que futuramente venham fazer a disciplina. Também estão presentes (classe 3), as palavras "produção", "feedback", "professores" e "acompanhar", estabelecendo o local como EPR-UnB e o papel fundamental do professor como o responsável por acompanhar e dar o feedback. Assim este núcleo pode-se chamar de atores da disciplina. Em seguida apresenta-se derivado do grupo nomeado "atores da disciplina" e isolado a classe 7, com palavras como "turma", "gerar", "comunicação" e "mudança", que aparecem no discurso como a sensação de pertencimento do grupo, uma melhoria na integração da disciplina, comunicação e o limitante de muitas mudanças no escopo. Assim este grupo será chamado de coletivo. A classe 6 também aparece derivada da 7, e traz palavras como "controle", "tarefa" e "documentação", que representam o decorrer da disciplina, marcada segundo o discurso desta classe pelo excesso de documentação e falta de controle, fazendo que este núcleo seja chamado de "processo". A classe 5 aparece derivada do grupo "processo" e é marcado com as palavras "equipe", "diferente" e "interação", denotando os efeitos das disciplinas nas equipes, que em sua maioria se sentiram mais integradas, porém em alguns casos acharam a divisão de trabalho injusta, embora tenha sido organizada pelas próprias equipes. Esta classe será chamada de "equipe" e se diferencia da categoria "coletivo", pois nesta última a preocupação reside em toda a sala.

Figura 5 – Análise de classes



Fonte: própria. Extraído do Iramuteq

Por último o núcleo com as classes 1 e 2, que são conformados de palavras como "ágil", "informação", "fraco" e "não" (classe 2), que explicam o sucesso do método ágil e a negativa em apresentar características negativas do método e as palavras "documento", "atividade", "tradicional" e "fraco", que revela as características da metodologia tradicional, que aparece como importante para organizar as atividades, porém com exagero na documentação. Assim, este núcleo se chamará "projetos".

Assim pode-se perceber que as categorias por ordem de importância são Projetos (29%), Atores da disciplina (26%), Equipe (17,4%), Processo (14,5%) e Coletivo (11,6%). Deste modo, a análise revela que seu foco foi alcançado tendo como ponto máximo a reflexão a respeito dos tipos de metodologias de projetos, seguido do papel fundamental dos atores desta disciplina, principalmente os professores, no que diz respeito aos *feedbacks*. Foi ressaltado que o legado ficou marcado pelo impacto das mudanças percebidas por cada equipe ao trabalhar diferentes métodos e a necessidade de formalizar mais o processo da disciplina. Finalmente, o mais importante, o resultado final satisfatório, que foi influenciado pelo trabalho em equipe (coletivo de sala de aula), melhorando a integração e comunicação entre os alunos.

6 Conclusão

O objetivo deste estudo foi compreender as percepções dos alunos sobre uma nova disciplina executada via PBL. Os resultados permitem afirmar que a disciplina superou as expectativas e alcançou seu propósito de fazer os alunos refletirem sobre as metodologias de projetos. Como legado, foi realizado um evento no auditório da Faculdade de Tecnologia, visando apresentar a comunidade acadêmica temas relacionados às metodologias de projetos, divulgar o site que foi desenvolvido, relatar suas experiências com as metodologias de projetos e oferecer acesso aos conteúdos trabalhados. Os resultados foram mensurados via questionário, assegurando que os alunos ficaram satisfeitos. O evento conseguiu envolver 274 discentes que assistiram aos resultados do trabalho entregue pelas equipes, que se concretizou no evento "Agilizando Projetos" por meio da execução de um projeto tradicional e na construção do site "producaounb.com.br" que foi desenvolvido com a metodologia ágil.

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Project-Based Learning in a Material Engineering Course of the Academic Unit of Cabo de Santo Agostinho (UACSA-UFRPE): An analysis according to the perspectives of the students.

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Abstract

The present article approaches the experience of the Academic Unit of Cabo de Santo Agostinho - UFRPE Engineering Campus, through the use of the Project Based Learning (ABP) methodology. For this purpose, a questionnaire was used at the end of the semester, aimed at the students of the first period of the Materials Engineering course, in order to evaluate the experience of the use of the ABP methodology in the subject of Materials Engineering. The results are mainly based on the students' current understanding of the PBL and its advantages and disadvantages as a teaching method. The research carried out through the questionnaire reveals that the students believe that the ABP methodology awakens the cognitive ability of the learner through practical activities and problem solving. Among the advantages cited by the students are the development of competences for the course and for professional life, teamwork, the search for knowledge through research. Although they point out several advantages of BPA, students point out some obstacles to BPA, such as: application in the first period of the course, lack of physical space and instruments, and lack of interrelations between project contents and other disciplines. Such considerations must be observed in order that the use of the BPA does not undermine its application.

Keywords: Project-Based Learning, Materials Engineering, ABP, UACSA-UFRPE.

Aprendizagem Baseada em Projetos em um Curso de Engenharia de Materiais da Unidade Acadêmica do Cabo de Santo Agostinho (UACSA-UFRPE): Uma análise segundo as perspectivas dos discentes

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Resumo

O presente artigo aborda a experiência da Unidade Acadêmica do Cabo de Santo Agostinho - *Campus* das Engenharias da UFRPE, através do uso da metodologia de Aprendizagem Baseada em Projetos (ABP). Para tal, foi utilizado, ao final do semestre letivo, um questionário voltado aos discentes do primeiro período do curso de Engenharia de Materiais, com o objetivo de avaliar a experiência do uso da metodologia ABP na disciplina Tópicos de Engenharia de Materiais 1A. Os resultados apresentados baseiam-se, sobretudo, no entendimento atual que os estudantes trazem acerca da ABP e suas vantagens e desvantagens enquanto método de ensino. A investigação realizada através do questionário revela que os discentes acreditam que a metodologia ABP desperta a capacidade cognitiva do educando por meio de atividades práticas e resolução de problemas. Entre as vantagens citadas pelos discentes está o desenvolvimento de competências para o curso e para a vida profissional, o trabalho em equipe e a busca de conhecimento por meio de pesquisas. Embora apontando diversas vantagens da ABP, os discentes apontam alguns entraves à mesma, como: a aplicação no primeiro período do curso, a inexistência de espaço físico e instrumentos e a pouca inter-relação dos conteúdos do projeto com as demais disciplinas. Tais considerações devem ser observadas a fim de que o uso da ABP não venha a desfavorecer a sua aplicação.

Palavras-Chaves: Aprendizagem Baseada em Projetos, Engenharia de Materiais, ABP, UACSA-UFRPE.

1 Introdução

As sucessivas revoluções industriais trouxeram importantes mudanças econômicas e sociais. A introdução da tecnologia digital na indústria está dando origem ao que é conhecido como Indústria 4.0[6], criando novos modelos de negócios e, portanto, novas formas de trabalhar. As empresas de hoje exigem um novo tipo de profissional capaz de combinar habilidades interdisciplinares com conhecimentos específicos, adaptando-se facilmente a diferentes demandas e ligando conhecimento de diferentes áreas. As universidades, portanto, precisam se adaptar para enfrentar este novo desafio. Recentemente, o ensino de engenharia no Brasil, tem se voltado, ainda que bem lentamente, a uma proposta que se diferencia do ensino tradicional pela forma como os alunos são convidados a participar do processo de aprendizagem. Essa proposta, chamada de aprendizagem ativa (PENAFORTE, 2001) permite aos alunos serem os protagonistas do processo de aprendizagem, através da resolução de problemas, ou da execução de projetos (POWELL e WEENK, 2003). Estudos têm demonstrado que a forma ativa de aprendizagem promove maior "produtividade" na classe, visto

[6] A incorporação da digitalização à atividade industrial resultou no conceito de Indústria 4.0, em referência ao que seria a 4ª revolução industrial, caracterizada pela integração e controle da produção a partir de sensores e equipamentos conectados em rede e da fusão do mundo real com o virtual, criando os chamados sistemas ciberfísicos e viabilizando o emprego da inteligência artificial.

que um número maior de alunos consegue atingir os objetivos da disciplina quando comparado ao ensino tradicional (FERNANDES, et. al., 2007), (CORREIA, et. al., 2016), (CARVALHO e LIMA, 2006).

Com o intuito de entender as necessidades e as percepções dos alunos que passaram por uma experiência de aprendizagem ativa (ABP – Aprendizagem Baseada em Projetos), este artigo analisa as perspectivas dos estudantes do 1º período do curso de Engenharia de Materiais que vivenciaram, no primeiro semestre de 2016, uma experiência com projeto interdisciplinar pautado em uma aprendizagem ativa e colaborativa.

2 Contexto do Estudo

A Unidade Acadêmica do Cabo de Santo Agostinho (UACSA) é o Campus das Engenharias da Universidade Federal Rural de Pernambuco (UFRPE). A UACSA oferece os cursos de Engenharia de Materiais, Mecânica, Civil, Elétrica e Eletrônica. Essa Unidade Acadêmica tem a missão de inovar o ensino de engenharia e promover a aproximação entre a universidade e as empresas, para que os alunos vivenciem o ambiente industrial, com suas características e demandas, sempre em constante transformação e que vem exigindo profissionais qualificados, capazes de se adaptar, dispostos a resolver problemas em equipe e motivados. Para isso se tornar possível, a aprendizagem ativa, através do método do Project Based Learning-(PBL), adotada aqui no Brasil como Aprendizagem Baseada em Problemas/Projetos-(ABP), foi escolhida pela UACSA como uma proposta integradora de ensino a fim de se contrapor ao modelo tradicional.

Nas matrizes curriculares dos cursos da UACSA, existe uma disciplina chamada de tópicos da engenharia, responsável por desenvolver atividades práticas, visitas técnicas e "projetos interdisciplinares".

3 Aprendizagem Baseada em Projetos/Problemas

O processo de reforma no campo da educação traz diversas mudanças, entre as quais o rompimento de estruturas rígidas e a superação do modelo de ensino tradicional (LIBÂNEO, 1992). As experiências inovadoras surgem em contraposição a esse modelo, buscando novas possibilidades no contexto educacional, para mobilizar os processos educativos de transformação. Dentre as diversas experiências inovadoras, está a Aprendizagem Baseada em Projetos. A Aprendizagem Baseada em Projetos surge a partir da experiência de um grupo de professores da Universidade de McMaster no Canadá, no final dos anos de 1960, na faculdade de medicina, e de lá se expandiu para muitas escolas de medicina em todo o mundo. Atualmente a ABP vem sendo trabalhada em diversas áreas do conhecimento, como, Administração (CAGGY, 2011), Engenharia (CORREIA et al., 2016), Enfermagem (BERBEL, 1998) nas áreas de Artes, Ciências e Humanidades (UVINHA e PEREIRA, 2010). Souza e Dourado (2015) afirmam que a ABP alcançou excelentes resultados no Canadá, Estados Unidos e por toda a Europa e atribuem o sucesso da metodologia às suas características: é um método centrado na aprendizagem, que tem por base a investigação para a resolução de problemas contextualizados e que envolve os conhecimentos prévios dos alunos, facilitando o desenvolvimento das competências necessárias ao trabalho profissional. Desenvolve a capacidade crítica na análise dos problemas e na construção das soluções, desenvolve a habilidade de saber avaliar as fontes utilizadas na investigação, bem como estimula o trabalho em equipe.

A ABP baseia-se na aprendizagem ativa e na busca pela desfragmentação do conhecimento a partir do diálogo entre as disciplinas, surge como uma proposta de articulação entre os saberes, apontando para uma cooperação entre as disciplinas ao focalizarem um objeto, propondo uma aproximação com a realidade. Segundo (CORREIA et. Al., 2016) essas correlações interdisciplinares desempenham o papel de eixo integrador entre as disciplinas do currículo, o que propicia ao discente ver um mesmo objeto sob diferentes ângulos, prática que o levará a responder aos problemas cotidianos que a vida lhe impõe com maior equilíbrio e competência. Diante disso, a ABP consolidou-se como um método sistematizado que permitiu aos professores das diferentes áreas e níveis de ensino, estimular a criatividade de seus alunos, desenvolver a capacidade investigativa e o raciocínio para a resolução de problemas (SOUZA e DOURADO, 2015), constituindo-se como um método eficaz nas mais diversas instituições de ensino e pesquisa em todo o mundo.

4 Metodologia

O acompanhamento, registro e análise da Aprendizagem Baseada em Projetos na turma de Engenharia de Materiais da UACSA foram feitos por meio de pesquisa de campo, utilizando como métodos de coleta de dados a observação e o questionário, caracterizando-se como uma abordagem qualitativa. Nesse trabalho apresentaremos apenas os resultados referentes ao questionário aplicado no final do semestre.

No caso da ABP de Engenharia de Materiais, optamos pelo questionário com uma questão aberta, em que os estudantes deveriam opinar sobre: a) o entendimento sobre a ABP e sua importância, b) as vantagens identificadas na execução do projeto, c) e as desvantagens percebidas durante o processo.

Segundo os autores (MARCONI; LAKATOS, 1999, P.100), o questionário é destinado a coletar dados de um grupo de respondentes, um "instrumento desenvolvido com perguntas ordenadas de acordo com um critério pré-determinado e que deve ser respondido sem a presença do entrevistador". Diante disso, o questionário foi aplicado por uma servidora ligada à área pedagógica, que já vinha realizando um acompanhamento pedagógico durante a vivência do projeto. O mesmo foi distribuído em sala de aula, em um momento reservado para este objetivo. O referido instrumento foi respondido por 44 discentes, entre homens e mulheres, da turma de Tópicos de Engenharia de Materiais 1A, componente curricular obrigatório do curso de Engenharia de Materiais.

5 A Experiência com (ABP) no Curso de Engenharia de Materiais da UACSA

Inicialmente foi formada a equipe de tutores, composta pelos docentes envolvidos nas disciplinas do semestre que deram apoio pedagógico ao projeto. A equipe de tutores compôs-se de professores de Desenho Técnico 1, Português Instrumental 1, Física Geral 1 e o suporte pedagógico do Apoio Didático da UACSA.

O projeto parte de um problema contextualizado, interdisciplinar e aberto, apresentado aos alunos, tendo como objetivo criar um protótipo de uma **cadeira de rodas construída com materiais provenientes de descarte**, que se adequasse aos seguintes requisitos e restrições: *ser construído com materiais oriundos de descarte, reciclagem ou reutilização; ser ergonômica; ser durável; ter baixo custo de produção.*

Para apresentar aos alunos a proposta, foi elaborado e apresentado um "Guia da Disciplina" que descrevia como a disciplina aconteceria, quais eram seus objetivos, quais as disciplinas que inicialmente estavam sendo evocadas a auxiliar na execução do projeto e as formas de avaliação.

A turma, dividida em 10 grupos, precisou criar um *blog,* em que os trabalhos seriam publicados e atualizados semanalmente, como um "diário de bordo". Adicionalmente, os alunos assistiram a uma apresentação sobre Ergonomia preparada pelo professor de Desenho Técnico 1, a fim de receberem instruções sobre dimensões básicas envolvidas em um projeto de cadeira de rodas e fontes de informação importantes para consulta.

O processo de avaliação foi realizado em apresentações orais e relatórios de atividades. Foram feitas três apresentações orais, sendo a primeira relativa ao planejamento inicial; a segunda relativa às atividades parciais feitas até a metade do semestre e a terceira referente à conclusão do projeto. Foram também apresentados dois relatórios de atividades, parcial e final.

Também como itens avaliativos, ao final do semestre, foram realizadas duas avaliações, a Avaliação dos Pares e a Autoavaliação, visando registrar a opinião a respeito dos integrantes do grupo e de si mesmos, relativa a seis critérios: Assiduidade, Empenho, Criatividade, Relacionamento e Comunicação Interpessoal, Cumprimento dos prazos e Soluções técnicas. A atividade possibilitou um momento de reflexão sobre a experiência vivenciada.

6 Análises dos Dados

A análise dos dados foi pautada em alguns princípios da técnica de análise de conteúdo de Bardin (1977), segundo a autora a análise de conteúdo pode ser definida como um conjunto de técnicas de análise das comunicações visando obter, por procedimentos sistemáticos e objetivos de descrição do conteúdo das mensagens, indicadores que permitam a inferência de conhecimentos relativos às condições de produção e recepção destas mensagens. Para a utilização do método é necessária à criação de categorias relacionadas ao objeto de pesquisa. As deduções lógicas ou inferências que serão obtidas a partir das categorias serão responsáveis pela identificação das questões relevantes contidas no conteúdo das mensagens. Diante disso, categorizamos os dados do questionário em três grandes blocos, sendo eles: a) entendimento dos discentes sobre a ABP; b) vantagens identificadas na execução do projeto e c) os desafios encontrados durante a vivência do projeto.

Com relação ao primeiro bloco, ***o entendimento dos discentes sobre a ABP***, após o processo de categorização, tivemos como categorias finais: 1- *Metodologia de resolução de problemas que desenvolve atividades práticas* e 2- *Método de trabalho com projetos*. Verificou-se que 91% dos discentes têm um entendimento claro acerca da metodologia utilizada, reconhecendo-a como uma metodologia baseada na resolução de problemas, desenvolvidas através de projetos, que auxilia no processo de aprendizagem, desenvolvendo atividades práticas, contribuindo assim para o processo de formação dos futuros engenheiros. Já 9% dos discentes não definiram a ABP, apresentando apenas as suas contribuições e desafios. Para uma melhor compreensão, segue alguns trechos das falas dos estudantes que apresentaram seus entendimentos a respeito da ABP:

> *"Metodologia nova que ajuda o desenvolvimento do discente. Visão ampla de análise, participar de situação real de desenvolvimento de um projeto."*
>
> *"Método de ensino baseado na resolução de problemas propostos através de projetos."*
>
> *"Ótimo modelo de aprendizagem, principalmente para estudantes de engenharia."*

Os alunos definem a ABP como um método de ensino que traz diversas vantagens, principalmente no que diz respeito à formação do engenheiro. Garcia (2014) aponta que a adoção do método ABP melhora, de uma forma geral, o ensino de Engenharia, pois benefícios como aumento da motivação, desenvolvimento da autonomia e da capacidade de autoaprendizagem para a vida toda "*lifelong learning*" têm sido observados na aplicação do ABP.

Outro ponto trazido nas falas dos estudantes é a questão da problematização. Os estudantes compreendem que a ABP é uma metodologia que trabalha a partir da resolução de problemas e que isso ajuda em seu processo de formação. Sobre isso, podemos considerar os estudos do Barrows e Tamblyn que, na década de 1980, já definiam a ABP como um método educacional que faz uso de problemas da vida real, servindo de estímulo para o desenvolvimento do pensamento crítico, de habilidades de resolução de problemas e da aprendizagem dos conceitos que integram os conteúdos programáticos.

Um elemento também citado nas falas dos estudantes em relação ao entendimento sobre a ABP foi a questão da interação. Souza e Dourado (2015, p.185), em seus estudos sobre a ABP como um método de aprendizagem inovador para o ensino educativo, afirmam que o benefício da interação que a ABP promove é fundamental para alcançar o sucesso na sua aplicação. Isso porque ela é "necessária em todos os sentidos: com o tema e com o contexto do tema estudado, entre os alunos e o professor tutor; enfim, entre todos". De acordo com essas várias definições sobre a ABP, percebemos que o entendimento dos estudantes de maneira geral se aproxima das conceituações trazidas pelos autores citados, pois entendem que a ABP promove a aquisição de conhecimentos, apresentando-se assim como uma metodologia que promove uma aprendizagem integrada e contextualizada.

O segundo bloco resultante de nossa análise, diz respeito às ***vantagens na utilização da ABP***. Foram registradas sete características da ABP consideradas, pelos estudantes, como vantajosas, sendo elas:

Vantagens na utilização da ABP
Importância das atividades práticas
Trabalho em equipe
Motivação para a busca de conhecimento/informação
Liderança
Relações interpessoais
Resolução de problemas
Pesquisa

Figura 1. Tabela de vantagens da ABP

Discutiremos a seguir algumas dessas vantagens, iniciando com o *Trabalho em Equipe*. Na ABP o trabalho em equipe é uma condição fundamental para o bom desenvolvimento da metodologia. Barrett e Moore (2011) destacam o trabalho em grupo como uma maneira de valorização da convivência, em que os estudantes se propõem a participar, de forma criativa, do processo de aprendizagem, objetivando criar espaços para o trabalho cooperativo, no qual todos são protagonistas, colaborando para uma aprendizagem mútua e integral. O trabalho colaborativo, desenvolvidos nas equipes, é na verdade, uma característica intrínseca às abordagens de aprendizagem ativa, como propõe a ABP. Autores como Mesquita; Lima e Pereira (2008), afirmam que é uma competência bastante procurada e valorizada pelos empregadores de diplomados.

O *Relacionamento Interpessoal* foi outro elemento apontado pelos estudantes. Souza e Dourado (2015, p.196), também apresentam habilidades interpessoais como uma vantagem da ABP, defendendo que esta proporciona aprendizagem não só de resultados das atividades acadêmicas de investigação, mas, também, "busca alcançar aprendizagens mais amplas de caráter educativo interpessoal para desenvolver habilidades afetivas, de convivência e de personalidade dos alunos".

Outros elementos destacados nas falas dos estudantes, e que são atribuídos como vantagens, foram a *motivação para busca de conhecimento e a pesquisa*. Os alunos afirmam que a ABP desperta a motivação para a busca de conhecimento e ao mesmo tempo em que os leva à pesquisa. Sobre isso, Campos; Ribeiro e Depes (2014) afirmam que com a ABP, os alunos aprendem de forma autônoma e colaborativa, constroem e reconstroem seus conhecimentos mediados pelas atividades recorrentes do método e pelas novas funções que tanto alunos quanto tutores precisam exercer. Somando-se a isso, através do uso da ABP, desenvolvemos a habilidade de pesquisa, trazendo essa prática para dentro dos cursos de graduação, em vez de limitá-la à pós-graduação.

Os alunos também apontam a *liderança* como uma vantagem do trabalho com ABP, afirmando que essa competência traz um diferencial no seu processo de formação, pois auxilia no desempenho profissional na hora de tomar decisões e delegar tarefas. Sobre isso, Barreto et. al., (2017) afirmam que liderança é uma competência que o mercado profissional busca nos futuros engenheiros para o enfrentamento dos desafios do mercado de trabalho. Diante disso, percebemos que os próprios estudantes já identificam vantagens que vão além de seu papel enquanto estudante e que estão mergulhados no ambiente acadêmico, levando em consideração o mundo do trabalho.

Por fim, os estudantes também trazem como vantagens a *resolução de problemas e as atividades práticas*. De uma forma geral os estudantes afirmam que a ABP os mobilizam a buscarem soluções para os problemas da vida real e os auxiliam no desenvolvimento de atividades práticas. Entendemos, com isso, que os estudantes percebem que a ABP promove o interesse pelo próprio aprendizado ao terem contato com a aplicabilidade dos conceitos aprendidos no curso, além de levá-los ao desenvolvimento de um senso crítico e empreendedor. Correia et. al., (2016) também partilham da ideia de que a resolução de problemas e as atividades práticas desenvolvem nos alunos o interesse por sua aprendizagem, a criticidade, o espírito empreendedor, a capacidade de trabalhar em grupo, de analisar e solucionar problemas e planejar experimentos, simulando as situações encontradas no dia-a-dia pelos engenheiros.

Como toda proposta inovadora, que busca romper com estruturas rígidas e tradicionais de ensino, também identificamos desafios para a vivência de uma prática pedagógica orientada pela aprendizagem ativa, como é a proposta da ABP. Para finalizar, apresentaremos o nosso terceiro bloco, ***Os Desafios enfrentados na utilização da ABP***. Elucidamos esses desafios através da seguinte tabela:

Os Desafios enfrentados na utilização da ABP
Vivência da ABP no primeiro período do curso
Ausência de um espaço físico adequado
Falta de oficinas, laboratórios e ferramentas
Falta de inter-relação entre os conteúdos vistos em sala e o projeto executado.

Figura 2. Tabela de desafios na ABP

Por ser um método centrado no estudante e, consequentemente, exigir um maior envolvimento e participação do aluno, imprescindíveis em metodologias como a ABP, a vivência dessa experiência no primeiro período foi trazida pelos estudantes como um desafio, uma vez que este maior comprometimento também acarreta um aumento do tempo e da carga de trabalho, o que é apontado como uma das desvantagens da metodologia e um dos pontos de insatisfação de alunos mais recorrentes na literatura sobre a ABP (RIBEIRO e MIZUKAME, 2008). Na opinião dos estudantes, os conhecimentos teóricos necessários ao desenvolvimento do projeto ainda não foram adquiridos por eles em uma etapa tão inicial como é o primeiro período. Em contrapartida, Correia et. al. (2016) mostram em uma avaliação da ABP em um curso de Engenharia Mecânica, que os discentes concordam com a aplicação da ABP a partir do primeiro período. Podemos inferir com isso, que a depender de como a ABP for conduzida, ela pode ser uma proposta pedagógica adequada para ser vivenciada no primeiro período do curso.

Outro elemento citado como desafio é a falta de infraestrutura, como laboratórios, oficinas e ferramentas. Souza e Dourado (2015) também trazem a infraestrutura como uma questão importante a ser observada. Segundo eles, a necessidade do apoio institucional em termos de incentivo, suporte pedagógico e infraestrutura são elementos que garantem uma boa eficácia da metodologia.

Por fim, os discentes também apontaram como um desafio a ser vencido no uso da ABP, a falta de inter-relação entre os conteúdos vistos em sala de aula e o projeto executado. Para os discentes essa ausência dificulta o processo de execução, devido, principalmente, à falta de embasamento teórico que poderia ter sido complementado em sala. Importante registrar que a ausência de inter-relação dos conteúdos abordada pelos discentes, nada mais é do que a ausência da interdisciplinaridade, importante característica das metodologias ativas, em especial a ABP. Em Bender (2014), vemos que enquanto metodologia ativa, a ABP pode ser definida pela utilização de projetos interdisciplinares, autênticos e realistas, visando o ensino de conteúdos acadêmicos. Esse entendimento acerca da interdisciplinaridade faz toda a diferença, pois o docente em sala de aula precisa articular os conteúdos apresentados com o projeto desenvolvido por meio da ABP, a fim de facilitar a assimilação dos mesmos, levando os discentes a um aprendizado integral e uma prática significativa, através de uma relação dialógica entre sujeitos e disciplinas.

Os aspectos positivos e desafiantes do trabalho com a ABP são vistos na literatura através de várias experiências analisadas sob a ótica dos estudantes e dos professores e em várias áreas do conhecimento. Daltro e Ponde (2017) em uma pesquisa sobre “Aprendizagem baseada em problemas: uma estratégia para a formação do Psicólogo como profissional de saúde” investigou a percepção de estudantes de psicologia sobre a exposição ao método de Aprendizagem Baseada em Problemas (ABP). Nela, os autores afirmam que os alunos percebem a importância do desenvolvimento de atitudes interdisciplinares, de comunicação, pesquisa, autonomia e amadurecimento pessoal que a vivência com a ABP trouxe para eles. A pesquisa discute também a importância do deslocamento do professor para uma posição de pesquisador como importante elemento para o desenvolvimento integral de competências atitudinais, conceituais e técnicas.

Por fim, mesmo este estudo sendo um caso específico sobre a experiência dos estudantes com a ABP e acreditando que essa metodologia tem se apresentado como uma alternativa de romper com o ensino tradicional que leva o aluno um lugar de passividade, não se defende que a mesma seja a única metodologia de ensino a ser vivenciada e muito menos que ela seja compreendida como a panaceia de todos os males da educação. Espera-se que esse artigo sirva como uma importante reflexão a respeito dos elementos positivos e desafiantes que a experiência com a ABP nos traz e que potencialize o desenvolvimento de outros estudos, destacando-se a necessidade de desenvolver novas investigações que contemplem também a percepção do docente. Como limitações deste estudo, destaca-se o fato de, por impossibilidade de espaço físico, não poder reproduzir na íntegra os resultados individuais das categorias de análise. Assim como o fato de não descrever a análise dos dados de uma pesquisa que versa sobre o tema Aprendizagem Ativa. Sugere-se que futuros estudos, elucidem a aplicação da análise de conteúdo a outros temas do campo das engenharias, contribuindo, assim, para a legitimidade da técnica e conquista de maior rigor e respeito por parte dos pesquisadores que a utilizam.

7 Conclusões

Os dados analisados no presente trabalho mostraram que os alunos que passaram por uma experiência de aprendizagem ativa por meio da Aprendizagem Baseada em Projetos (ABP) percebem aspectos positivos e negativos na forma como a metodologia foi aplicada. Os principais aspectos positivos apontados foram: a importância das atividades práticas; o trabalho em equipe; a motivação para a busca de conhecimento/informação; liderança; relações interpessoais; resolução de problemas e pesquisa. Já os aspectos negativos relacionaram-se à vivência da ABP no primeiro período do curso; a ausência de um espaço físico adequado, como oficinas, laboratórios e ferramentas e a falta de inter-relação entre os conteúdos vistos em sala e o projeto executado. Espera-se que tais aspectos sejam levados em consideração na elaboração de estratégias baseadas em ABP a serem futuramente aplicadas em outros períodos deste curso e também em outros cursos da unidade acadêmica. Considera-se, enfim, que a escolha pelo uso do método ABP pode constituir-se como uma estratégia de fortalecimento de uma educação transformadora no âmbito das engenharias, fomentando o desenvolvimento da autonomia com consequente possibilidade de transformação social.

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Software Development as a Motivator to Learn Solid Mechanics

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Abstract

Solid Mechanics is a mandatory subject required by the Ministry of Education in all engineering curricula in Brazil. Some engineering specialties, such as Computer Engineering, are not intrinsically close to Mechanics. On such engineering specialties, there is a risk that Solid Mechanics is perceived as a boring arbitrary subject that just needs to be overcome. This work reports how a Solid Mechanics course for Computer Engineering was designed to leverage software projects, numerical methods and simulation in order to motivate the students. The pedagogical resources that were used included software design projects, feedback activities and student self-assesment. Students were encouraged to reflect upon their performance in relation to the learning goals of the course.

Keywords: Solid Mechanics; Numerical Methods; Project-Based Learning; Software Development.

Desenvolvimento de Software como motivador para Mecânica dos Sólidos

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Resumo

Mecânica dos Sólidos é um conteúdo básico determinado pelo Ministério da Educação que precisa estar presente na formação de todas as especialidades de engenharias no Brasil. Em alguns cursos mais afastados da Mecânica, por exemplo a Engenharia de Computação, os alunos podem perder a noção do propósito desta disciplina e passar a enxergar que o curso é apenas um requisito maçante a ser vencido. Este trabalho reporta o design de uma disciplina de Mecânica dos Sólidos baseada em projeto de software que incorpora métodos numéricos e simulação como forma de promover o engajamento de alunos de engenharia de computação. Como recursos pedagógicos, foram empregados um modelo integrado de avaliação baseado em desenvolvimento de software, atividades de feedback e de auto avaliação discente para incentivar a reflexão do aluno sobre seu desempenho em relação aos objetivos de aprendizagem propostos.

Palavras-chave: Mecânica dos Sólidos; Métodos Numéricos; Aprendizagem Baseada em Projeto; Desenvolvimento de Software.

1 Introdução

Existe uma percepção da evolução do papel dos engenheiros para que se mantenham relevantes no século XXI. Em uma visão mais tradicional, o engenheiro recebia demandas técnicas e propunha um projeto capaz de atender a aqueles requisitos, eventualmente levando em conta restrições econômicas e regulatórias.

No ambiente de projetos dinâmico dos dias atuais, é preciso que o engenheiro se engaje cada vez mais em questionar por que um projeto existe, e quais as necessidades de fato do usuário. Tem sido comum discutir como competências de empreendedorismo e de atitude de design (*design thinking*) são importantes para o ferramental do novo engenheiro (Goldberg, Sommerville, 2014).

Para melhor propiciar a formação deste engenheiro diferenciado, metodologias interacionistas (construtivismo e aprendizagem significativa) têm sido aplicadas com sucesso no contexto de engenharia. Recursos frequentemente empregados por estas metodologias são o aprendizado baseado em projetos (PBL) e a aprendizagem ativa.

No Instituto de Ensino e Pesquisa (Insper), propomos no programa de Engenharia proporcionar experiências de aprendizagem que sejam interativas, orientadas à discussão de problemas e tomada de decisão e centradas no repertório e experiências dos alunos. A partir destas premissas, faz sentido que se procure o máximo de contexto e afinidade ao desenvolver um curso de Mecânica dos Sólidos para a Engenharia de Computação.

2 Aprendizagem Baseada em Projeto de Software

O uso da tecnologia computacional para ensino assistido não é novidade. Já ao final dos anos 50, diante das possibilidades tecnológicas da época, conteúdos e sistemas computacionais foram desenvolvidos com fins educacionais. De um modo geral, a proposta desses sistemas era promover o aprendizado "construtivista", o que significa uma maior interação do aluno com o objeto de conhecimento (Baranauskas, Rocha, Martins, & D'Abreu, 1999).

Com o avanço da tecnologia dos computadores os sistemas evoluíram e o aluno passou a ocupar um papel cada vez mais central assumindo uma posição de agente para o desenvolvimento do ambiente computacional, o que possibilitou uma interação mais profunda com o objeto de conhecimento.

O “aprender fazendo e refletindo” em ambientes de modelagem e simulação associado às ideias de “aprender fazendo”, a aprendizagem baseada em projeto (Project Based Learning - PBL) tem se destacado nos últimos 25 anos.

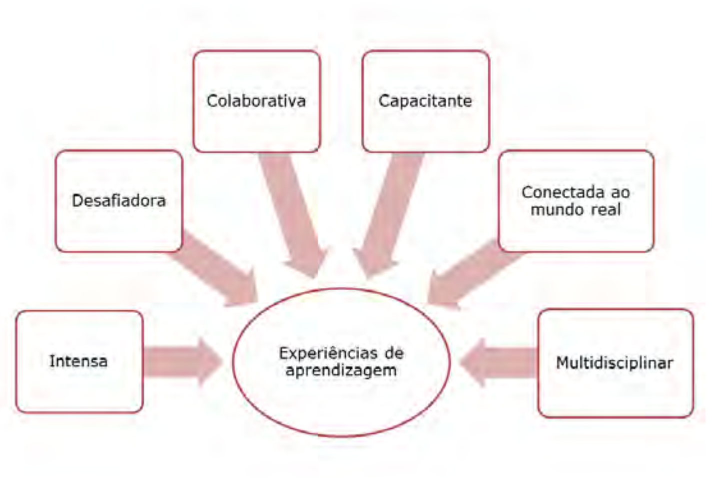
Características da aprendizagem baseada em projeto (Project Based Learning)

- O aluno é o centro do processo de aprendizagem.
- O aprendizado é um processo ativo, dinâmico, interativo e cooperativo, integrado, interdisciplinar e orientado ao aprendizado do aluno.
- O docente atua como um moderador das experiências de aprendizagem.

Essas características contribuem para uma maior compreensão dos conceitos e auxiliam o estudante no desenvolvimento de habilidades transversais como capacidade de análise, trabalho em equipe e resolução de problemas.

Dessa forma, o uso de modelos de ensino baseado em projeto implica no desenvolvimento de experiências de aprendizagem baseadas em dinâmicas de aula interativa, orientada à discussão de problemas e tomada de decisão e centrada no repertório e experiências dos alunos (Figura 1).

Figura 1. Desafios e a abordagem baseada em projeto de software.



3 Design da Disciplina de Mecânica dos Sólidos

Grande parte dos problemas práticos de engenharia envolvem problemas complexos que não apresentam solução analítica. Isso faz com que, em geral, grande parte desses desafios não sejam abordados em cursos de graduação. Por outro lado, verificamos cada vez mais a necessidade de formação de um engenheiro capaz de atuar em um mercado dinâmico onde a simulação numérica e o uso do chamado protótipo virtual são considerados ferramentas fundamentais diante de necessidades como redução de tempo e custo no desenvolvimento de novos produtos.

Aliado a esse contexto, o acesso a computadores com capacidades de processamento de dados cada vez maior, cria um ambiente interessante para o desenvolvimento de experiências de aprendizagem, em níveis de graduação, com características multidisciplinares e que permitam estabelecer conexões entre grandes áreas do conhecimento, que em boa parte dos cursos tradicionais são abordadas de modo isolado. Empiricamente observa-se que assuntos vistos de forma estanque contribuem para a falta de interesse e desmotivação dos alunos.

No processo de elaboração das experiências educacionais, uma etapa fundamental é a definição de objetivos de aprendizagem. Esses objetivos são declarações claras, passíveis de mensuração e inseridas em um dado nível cognitivo, relativas ao que o estudante deve compreender (conteúdos), incluindo o que deve ser capaz de fazer (habilidades), após participar das experiências propostas na disciplina.

Como premissas básicas elaboramos para o curso os seguintes objetivos de aprendizado, baseados no *framework* proposto por (Crandall, Dahl, & Lardner, 1978) e que apresenta de maneira geral os desafios conceituais para a modelagem e solução de problemas em mecânica dos sólidos (Figura 2).

Figura 2. Framework do procedimento de solução em problemas de mecânica dos sólidos.

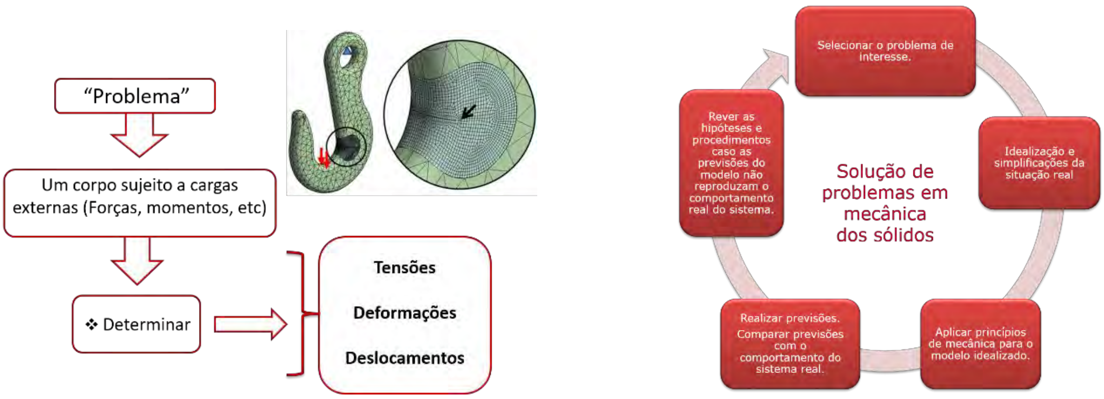
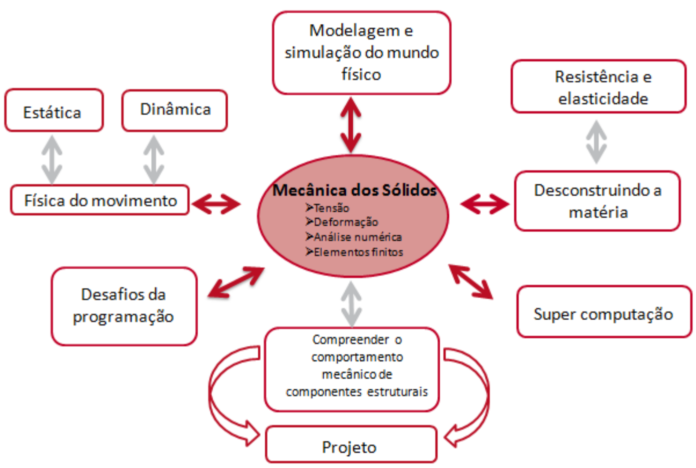


Tabela 1 - Objetivos de aprendizagem de Mecânica dos Sólidos

Objetivos de aprendizado
1. Saber calcular reações de apoio estrutural e analisar o comportamento de elementos de barra/viga sujeito a um carregamento aplicado. 2. Explicar e aplicar procedimentos para análise em estruturas reticuladas usando o processo de superposição dos elementos para a obtenção de matrizes e vetores globais. 3. Explicar e aplicar técnicas numéricas para a solução de sistemas de equações e equações diferenciais.

Com base nos objetivos propostos, e no mapa conceitual da disciplina (Figura 3) o aluno é capaz de identificar exatamente qual o objetivo da disciplina no curso, qual a sua relação com outras disciplinas do curso e o que os novos conceitos acrescentam em seu aprendizado. Ao estabelecer conexão dos novos conceitos, com conceitos preexistentes na estrutura de quem aprende, o aprendizado se torna significativo (Carvalho, Porto, & Belhot, 2001)e, portanto, o mapa conceitual pode ser associado ao ciclo da aprendizagem.

Figura 3. Framework da disciplina de mecânica dos sólidos. As setas em vermelho indicam relação com disciplinas básicas e avançadas do curso de engenharia de computação. As setas em cinza indicam relação com conceitos prévios.



Além disso, a montagem do mapa conceitual pode auxiliar o professor no planejamento e organização de experiências de aprendizado que contribuam para que o aluno conheça novos conceitos, contextualize esses conceitos, solidifique-os através de sua interação com o objeto de conhecimento e possa aplica-los em situações da vida real.

3.1 O Projeto de Software

A seguir apresentamos uma descrição do projeto desenvolvido ao longo de um bimestre e proposto aos alunos do 5º semestre do curso de engenharia de computação.

O projeto foi dividido em três etapas:

1. Projeto e protótipo

Nessa etapa solicitamos aos alunos que, usando um software comercial para análise de treliças elaborassem o projeto estrutural e a montagem do protótipo de uma treliça usando macarrão.

2. Desenvolvimento de software

Nessa etapa solicitamos aos alunos que com base em seus conhecimentos prévios de programação e nos conceitos desenvolvidos na disciplina, desenvolvessem a implementação computacional de um software com aplicações de técnicas numéricas (Figura 4) para análise de tração/compressão em treliças planas.

3. Validação e apresentação dos resultados.

Na última etapa os alunos deveriam apresentar a validação do software implementado. Além disso solicitamos a elaboração de um relatório contendo toda a documentação do programa implementado (Figura 5).

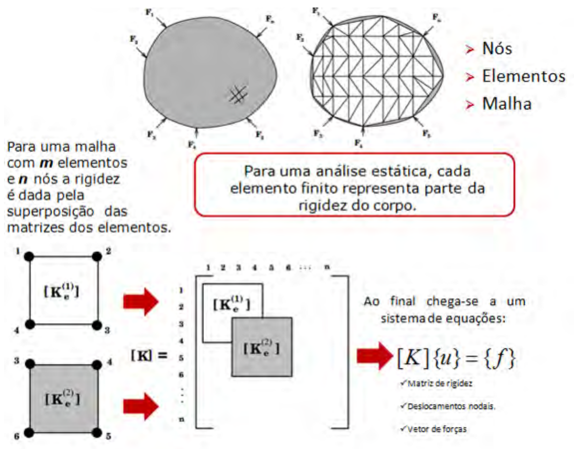
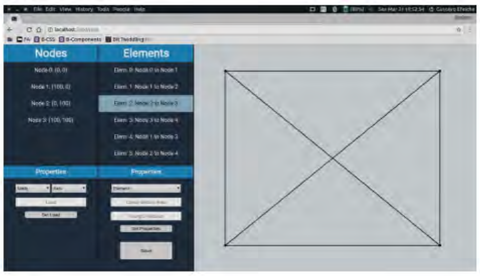
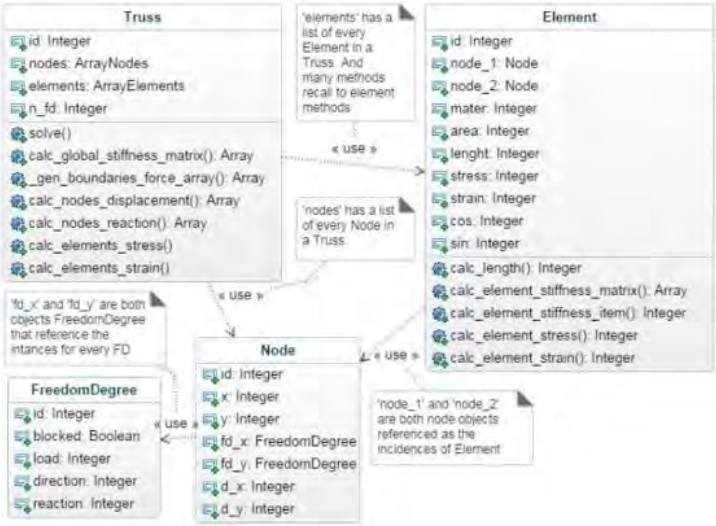


Figura 4. Superposição matricial para a montagem da matriz de rigidez global usando modelagem por elementos finitos(Bittencourt, 2014).

A escolha do ambiente de programação ficou a critério dos alunos exigindo-se apenas que o código implementado fosse escrito de modo que os dados de entrada pudessem ser facilmente alterados a partir de um arquivo de texto. Além disso, o programa deveria gerar um arquivo texto de saída apresentando o pós-processamento dos dados.

Figura 5. Diagrama de classes de um programa orientado à objetos em Python para resolução de treliças e interface gráfica para uso online do software





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Não menos importante que todo o planejamento de experiências de aprendizagem, a avaliação pode ser vista como o momento de coletar informações sobre o desempenho dos estudantes na disciplina para que ações possam ser consideradas no sentido de obter melhorias nos processos de ensino/aprendizagem. Essa visão nos distancia, de certo modo, dos conceitos tradicionalmente punitivos associados à avaliação.

Nesse sentido adotamos um modelo integrado de avaliação baseado em atividades que proporcionem ao professor a possibilidade de feedback rápido e contínuo ao longo das experiências de aprendizagem (aulas estúdio para desenvolvimento do projeto). Além disso, para verificação dos objetivos de aprendizagem propostos para a disciplina foram realizados dois testes conceituais abordando tópicos de mecânica dos sólidos com aplicações em modelagem e simulação numérica. Os testes apresentavam perguntas conceituais e práticas de implementação que deveriam ser superadas para que o aluno pudesse avançar nas etapas do projeto.

Outro ponto considerado na disciplina foi o uso de um modelo de avaliação discente. Nesse caso os alunos foram incentivados a refletir, baseado em "*rubrics*" sobre os objetivos de aprendizagem da disciplina, sobre seu desempenho em relação aos objetivos de aprendizagem propostos.

3.2 Considerações sobre a Abordagem de Ensino

Ao final do projeto um questionário foi colocado aos alunos com objetivo despertar a autorreflexão sobre a disciplina com base em suas considerações pessoais. Nosso objetivo foi compreender e avaliar:

- Como as experiências de aprendizagem adotadas na disciplina foram importantes para promover o desenvolvimento dos objetivos de aprendizagem propostos.
- Como a abordagem baseada em projeto de software e em um modelo integrado de avaliação, atividades de feedback e de auto avaliação discente contribuíram para promover o engajamento de alunos de engenharia de computação.

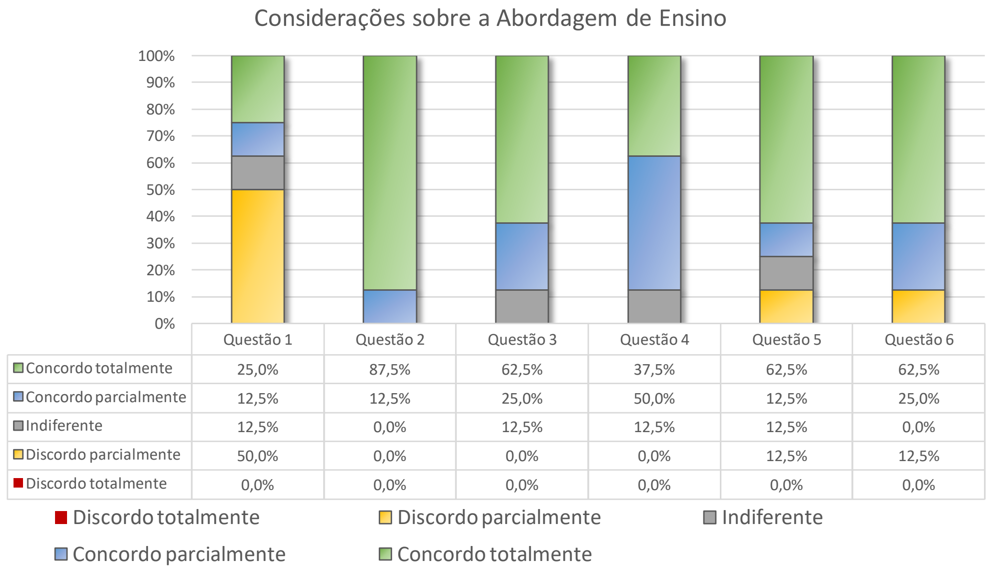
Para o questionário proposto, foram formuladas seis afirmações como descrito abaixo:

1. Antes de cursar a disciplina eu não tinha ideia da aplicação da disciplina no contexto de Engenharia de Computação.
2. O ensino baseado em projeto de software tornou o aprendizado dinâmico e interativo e contribuiu para que eu me engajasse.
3. Durante as experiências de aprendizagem propostas na disciplina, exercitei capacidade de análise, trabalho em equipe e resolução de problemas.
4. Refleti sobre como estava em relação aos objetivos de aprendizagem motivado pelas atividades de desenvolvimento de software, testes e feedback.

5. A abordagem utilizada na disciplina permitiu estabelecer relações entre áreas do conhecimento que acho que em cursos tradicionais seriam abordadas de modo isolado.
6. O software que eu construí me permitiu estabelecer conexões entre disciplinas básicas da engenharia e específicas do currículo do engenheiro de computação.

Para cada afirmação, solicitamos aos alunos que indicassem seu nível de concordância sendo (1) caso discordassem totalmente da afirmação e (5) caso concordassem totalmente com a afirmação.

Figura 6. Distribuição das respostas assinaladas pelos alunos.



	Questão 1	Questão 2	Questão 3	Questão 4	Questão 5	Questão 6
Concordo totalmente	25,0%	87,5%	62,5%	37,5%	62,5%	62,5%
Concordo parcialmente	12,5%	12,5%	25,0%	50,0%	12,5%	25,0%
Indiferente	12,5%	0,0%	12,5%	12,5%	12,5%	0,0%
Discordo parcialmente	50,0%	0,0%	0,0%	0,0%	12,5%	12,5%
Discordo totalmente	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%

A partir dos resultados do questionário respondido pelos alunos e indicados na Figura 6, podemos inferir que pelo menos 50% dos alunos tinham ideia de possíveis aplicações da disciplina mesmo antes de cursa-la. Esses conhecimentos prévios podem auxiliar o professor na preparação de experiências de ensino centradas no repertório e experiências dos alunos. Além disso, mais de 60% afirmaram que a abordagem alternativa de ensino, com atividades que possibilitem ao aluno exercitar sua capacidade de análise, trabalho em equipe e resolução de problemas, podem promover seu engajamento e participação nas aulas. Outro ponto importante é que diferentemente de cursos tradicionais onde a mecânica dos sólidos é vista de forma isolada, a abordagem utilizada na disciplina permitiu estabelecer relações entre áreas do conhecimento de modo que os alunos pudessem relacionar habilidades de sua especialidade (programação, projeto de software) e conceitos fundamentais em mecânica dos sólidos.

4 Conclusão

A abordagem centrada no aluno (ACA) permitiu transformar uma potencial resistência dos alunos à disciplina de mecânica dos sólidos em motivação e engajamento para o desenvolvimento do projeto. O uso de um projeto de software no contexto da disciplina destacou-se como uma metodologia centrada no aluno de engenharia de computação e que além de tornar o desenvolvimento da aprendizagem dinâmico e interativo auxilia no desenvolvimento de competências transversais.

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A Project-Approach of a simple control system for beginner students

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Abstract

This manuscript intends to present the project developed by the third semester students of Engineering Undergraduate Program from São Judas Tadeu University (SP - Brazil). This project used the CDIO methodology to design and build a load transportation system controlled by Arduino board. The prototype consisted in creating a pulley transmission system driven by a DC micromotor (approx. 0.5 W). The proposal integrates the knowledge developed among the semester, such as basic electromagnetic and electrical principles (how DC motors works), power and torque transmission (using gear or pulley transmission system's fundamentals) and Algorithms and Computer Programing (C language for Arduino IDE). The students must choose and define their solution proposal for the problem (e. g. rail system, elevator or table top conveyor), design the mechanical transmission (gearbox or pulley system), decide the DC motor specifications accordingly to the needed power as well as o design and build the final transportation system prototype. There are three intermediate presentations among the semester, each one discussed by the responsible professor. The students must present, firstly, the transmission system calculus and project. Secondly, they present the transmission system assembled and functional. Thirdly and finally, they present the final transportation system with the Arduino board as its controller, showing how they designed the control software and how it is operated. Parallel to the design and construction of the prototype, the students also develops a documentation of all the steps they followed until the final result, as well as the conclusion of the entire work. This document must follow a Article Template based on the most significant Engineering Symposiums. At the end of the semester, they present all the documents (article and intermediate reports) and the functional prototype to an Evaluation Committee of three professors: a president, the responsible professor and a external invited member.

Keywords: Active Learning, Arduino, Project-Led Engineering Education.

Projeto de um sistema de controle para estudantes em início do curso

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Resumo

Este artigo tem como objetivo apresentar o projeto desenvolvido no terceiro semestre dos cursos de Engenharia da Universidade São Judas Tadeu (SP- Brasil). O projeto, que utilizou a metodologia CDIO, consiste em se construir a maquete de um sistema de transporte de cargas controlada por Arduino utilizando motores DC (corrente contínua) de pequeno porte (0,5 W) e um sistema de redução. A proposta integra os conhecimentos desenvolvidos no semestre, como conceitos de eletricidade e eletromagnetismo básico (princípios de funcionamento de motores), transmissão de forças, torque (usados nos cálculos do sistema de redução por polias ou por engrenagens), Algorítmos e Programação (Arduino). Os alunos devem, definir o tipo de carga e de transporte a ser executado (esteira rolante, elevador, etc.), determinar o motor de corrente contínua a ser usado, bem como calcular e construir o sistema de redução. São feitas três rodadas de apresentação dos trabalhos intermediários (cálculo do sistema de redução, maquete do sistema de redução e programação do Arduino), com discussão dos resultados obtidos em cada etapa. Paralelamente, os alunos devem preparar um artigo científico para apresentar os resultados. Ao final do semestre, os alunos fazem uma apresentação formal do projeto funcional a uma banca de avaliadores.

Palavras-chave: Aprendizagem Ativa, Arduino, CDIO, Educação em Engenharia conduzida por Projetos.

1 Introdução

A matriz curricular dos cursos de Engenharia da Universidade São Judas Tadeu, tem em sua organização uma componente curricular chamada Projeto Interdisciplinar (PI). A disciplina coloca em prática, desde o início do curso, os conhecimentos desenvolvidos ao longo de cada semestre.

A disciplina é parte importante no contexto do Projeto Acadêmico dos Cursos de Engenharia, pois, além de tratar de temas que conectam os conhecimentos teóricos, traz ao estudante a possibilidade de trabalhar diversas habilidades sócio-emocionais como a capacidade trabalhar em equipe, autonomia, criatividade, comunicação oral e escrita, lidar e resolver problemas, espírito crítico, capacidade de análise, além de adquirir conhecimentos sobre a sua área de atuação profissional de forma ampla (Ânima, 2016).

Ao usar os projetos como forma de aprofundar e conectar conhecimentos, o aluno adquire também a possibilidade de um aprendizado que não se limita a reproduzir ou listar características, mas que permite relacionar e abstrair conhecimentos e ir além do que foi ministrado, de acordo com suas características e interesses (Biggs & Tang, 2011).

A disciplina se organiza em dois momentos: no primeiro momento, o professor propõe atividades que irão contribuir com o projeto, orienta e avalia o trabalho dos grupos durante o semestre. No outro momento, os alunos trabalham de forma autônoma, sem a presença do professor, é o tempo reservado para o grupo se reunir e trabalhar no projeto.

O projeto aqui descrito é realizado no terceiro semestre dos cursos de Engenharia, que apresenta as disciplinas de Algoritmos e Programação, Física (Mecânica e Eletromagnetismo Básico) e Cálculo (Holtzapple, 2013). A disciplina Projeto Interdisciplinar tem por objetivo conectar, de forma prática, os conhecimentos das demais disciplinas. Assim sendo, a proposta do projeto foi elaborada a partir dos conhecimentos abordados nas demais disciplinas do semestre (Dym, 2010).

Os projetos devem ser elaborados em grupos de 4 a 6 alunos, com alunos de diferentes habilitações de Engenharia (Civil, Computação, Controle e Automação, Elétrica, Eletrônica, Mecânica).

2 Descrição do Projeto

O projeto consiste em se construir o protótipo de um sistema de transporte de cargas movido por um motor de corrente contínua com sistema de redução (por polias ou engrenagens) que, por sua vez, será controlado por Arduino.

A carga deve ser movida por uma distância entre 0,60 m e 1,0 m. Além disso, a velocidade de transporte deve ser controlada de forma que exista uma aceleração no início do movimento até atingir a velocidade máxima e uma desaceleração até a parada total no final do movimento. O início da desaceleração deve, preferencialmente, ser acionado por um sensor de presença (que pode ser óptico, capacitivo ou magnético). A velocidade máxima deve estar entre 0,05 m/s e 0,10 m/s e deve ser determinada pelos grupos, atendendo-se a critérios pré-estabelecidos de distância e tempo (Medeiros, 2017).

A Figura 1 abaixo mostra o gráfico de velocidade da carga ao longo do transporte.

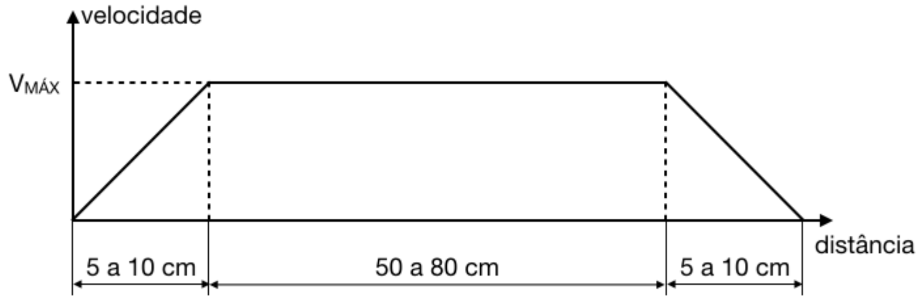

Figura 1: Gráfico de velocidades da carga no sistema em função da distância.

Como pode ser visto pela Figura 1, os grupos devem escolher a distância em que a carga deve se mover até atingir o ponto de velocidade máxima (distância d_{ACEL}) que deve ser a mesma para que ele desacelere até velocidade nula (distância d_{DESAC}). Além disso, a carga deve permanecer em velocidade constante por uma distância $0{,}5m \leq d_{CONST} \leq 0{,}8m$.

Além disso, os grupos devem atender a um tempo de percurso para cada trecho do projeto. A carga deve partir de velocidade nula e atingir sua velocidade de regime num tempo $3s \leq t_{ACEL} \leq 5s$, que deve ser o mesmo para a desaceleração. Já em regime, a carga deverá permanecer nesta velocidade por um tempo $5s \leq t_{DESAC} \leq 15s$.

Com os dados fornecidos acima, os alunos, ao escolherem o conjunto {tempo, distância}, calculam qual é a velocidade de regime da carga. Com esse dado e sabendo qual a rotação em plena carga do motor utilizado, é possível calcular qual a relação de redução necessária para projeto do redutor.

Os motores usados pelos grupos são fornecidos pela instituição. Eles consistem em micro motores de corrente contínua com potência nominal de saída variando entre 0,5W e 2,0 W, tensão de entrada de 5V a 12V e rotação de saída de 2.400rpm à 9.700rpm.

Após os dados de projeto terem sido escolhidos, os alunos definem então qual o melhor sistema de transporte a ser implementado. Dentre os vários tipos, são sugeridos: elevador, esteira transportadora, talha elétrica, entre outros.

Em uma etapa seguinte, o tipo de sistema de redução também é uma escolha particular do grupo. Em aula é ensinado a montagem de sistemas de transmissão por polias, contudo é possível e está dentro dos parâmetros de projeto o uso de sistemas de redução por engrenagens e até a utilização mista de engrenagens e polias.

3 Atividades de Apoio ao Projeto

Nos horários de acompanhamento, o professor propõe diversas atividades que servirão de apoio ao projeto. A primeira delas é a conceituação das partes de um sistema de redução e a construção prática e medida de alguns sistemas de redução por polias, verificando a relação entre diâmetros e rotação das polias. A construção é simples e feita com papelão rígido e barbantes. São construídas polias de vários diâmetros e medidas as relações entre as rotações.

Uma vez que os alunos definiram o seu protótipo, os grupos apresentam os cálculos para o sistema de redução para o seu projeto.

A segunda atividade de apoio é sobre metodologia científica e artigos científicos. Como parte da avaliação final, os alunos devem entregar os resultados do projeto no formato de um artigo científico. O site da disciplina fornecerá um *template* mas, como são estudantes em fase inicial, é importante um primeiro contato com um artigo científico. Esse o elemento de comunicação escrita que será trabalhado e avaliado no semestre. Nos semestres seguintes serão trabalhadas outras formas de comunicação escrita e oral.

Para complementar, o professor irá conduzir algumas atividades de orientação de programação específica para o Arduino e também de suas conexões externas.

A integração entre a parte de construção e o Arduino, testes e ajustes finais compõem a etapa "Operar".

4 Desenvolvimento do Projeto e Entregas

A primeira tarefa dos alunos será a de organizar os grupos de projeto. Uma vez formados, os grupos têm um prazo de duas semanas para definir o seu projeto (etapa "Conceber" na metodologia CDIO), determinando o que será feito, as dimensões, velocidades e um croqui do projeto final. A partir desse momento, os grupos iniciam o seu Caderno de Acompanhamento (Diário de Bordo), que será um registro das atividades do grupo, reuniões, materiais a serem utilizados, desenhos, montagens, relacionando com os conteúdos das disciplinas e estabelecendo os passos seguintes.

Semanalmente, o professor irá verificar o caderno, ajudando na orientação. No caderno, o grupo deve indicar a data, as atividades desenvolvidas na semana anterior, comparando com o que era planejado e justificando a importância da atividade, acrescido de um relato sobre os conhecimentos das demais disciplinas que ele utilizou para executar a atividade. Este relato é importante para que os alunos percebam, a cada momento do projeto, que estão acionando conhecimento das outras disciplinas e dando significado ao que foi aprendido. Por último, o grupo indica as ações a serem desenvolvidas na próxima semana, mostrando a importância do planejamento das atividades.

Duas semanas após a definição do projeto, o grupo apresenta os cálculos para o seu sistema de redução, também registrados no diário de bordo, que será conferido pelo professor orientador (esse é o início da etapa "Desenhar", ou Projetar do CDIO).

A etapa de montagem do sistema de redução deve ser completada duas semanas depois da entrega dos cálculos ("Implementar" no CDIO). Essa etapa de montagem é a mais crítica, visto que os maiores problemas (atrito e desalinhamento nas polias ou engrenagens) aparecem nessa construção. Os grupos terão um tempo adequado para corrigir, melhorar e finalizar a construção do seu projeto.

Enquanto o grupo realiza as melhorias necessárias, inicia-se a programação do Arduino. Essa programação é relativamente simples, pois trata-se do controle de velocidade de um motor de baixa potência, não necessitando amplificadores ou outros circuitos eletrônicos.

5 Avaliação

A avaliação do projeto leva em conta todo o seu desenvolvimento e a participação dos alunos nas atividades. Embora o trabalho seja realizado em grupo, a avaliação é individual, razão pela qual o professor deve acompanhar e dialogar com o grupo, de forma a verificar a participação e o envolvimento de cada aluno na construção do projeto mas, principalmente, na construção do próprio conhecimento.

A avaliação é dividida em duas partes, uma processual, que avalia o desenvolvimento do projeto, o cumprimento dos prazos ao longo do semestre e a participação individual (que compõe 90% da nota) e outra avaliação final, que leva em conta apenas o produto final e a sua apresentação (compõe 10% da nota). O portfólio, com o caderno de acompanhamento, cálculos parciais, desenhos, programa fonte do Arduino e avaliação da participação de cada aluno constituem a Avaliação processual do trabalho, levando em conta a participação individual.. A nota pode ser diferente para alunos do mesmo grupo, de acordo com a presença e a avaliação pelos pares (feita através de um formulário apropriado).

A avaliação final, que constitui na apresentação do protótipo e no relato dos resultados na forma de um artigo científico é feita para uma banca examinadora e perante toda a turma.

6 Resultados

A criatividade esteve presente nas construções. Muitos alunos, a partir dos próprios interesses, incluíram outras características ao projeto, como por exemplo tela de toque conectada ao Arduino para controle e acompanhamento do processo, controles e monitoramento por *Bluetooth* e *Wi-Fi* conectados a aparelhos móveis.

A Figura 2 mostra, à esquerda, a implementação de uma tela sensível ao toque para controle da esteira. Essa tela funciona como uma '*shield*' para o arduino e como uma interface homem máquina para o usuário. Já a direita da Figura 2, a interface de interação é feita através de um aplicativo de celular. Os alunos, utilizando do App Inventor, plataforma criada pelo MIT, desenvolveram o próprio aplicativo para sistema Android, a fim de facilitar o uso por deficientes físicos.

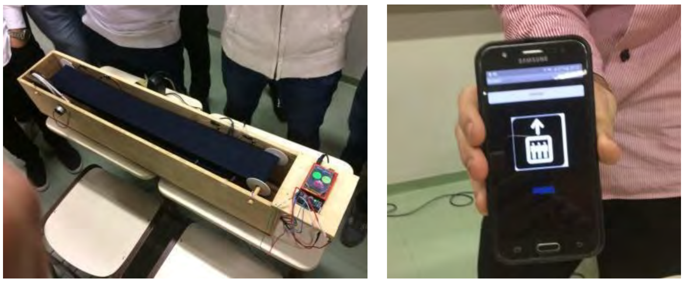

Figura 2: À esquerda, esteira com tela de toque, à direita controle por *Bluetooth* em *Smartphone*.

Além da imaginação para criação das interfaces de comando, viu-se também a preocupação de se criar sistemas de redução e mecânicos de transporte bem criativos. Na Figura 3 abaixo, ilustra-se uma das caixas de redução criada por um grupo da Engenharia Mecânica.

Figura 3: Caixa de Redução por Polias com Ajuste de Tensão da Correia do Primeiro Estágio.

A Figura 3 mostra uma caixa de redução que apresenta a possibilidade de ajuste manual da tensão da correia do primeiro estágio. Com isso, os alunos podem controlar a tração dada pelo motor e o escorregamento máximo desejado. Caso o grupo precisasse trocar o motor por outro mais forte, é possível ajustar o escorregamento para que o sistema trabalhe de modo mais eficiente para o novo motor.

Outra preocupação que também foi vista em alguns grupos foi com a possibilidade de se adaptar o percurso de desaceleração. Isso foi resolvido por um dos grupos da Engenharia Mecânica através de um sistema mecânico de posicionamento do sensor de presença. Essa solução pode ser vista na Figura 4 abaixo:

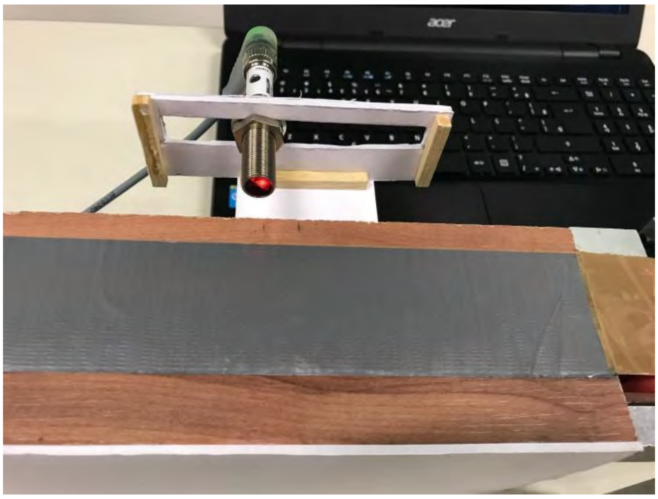

Figura 4 - Sistema Mecânico de Ajuste do Sensor de Presença.

A Figura 4 ilustra que o sensor pode ser mudado de posição, permitindo que a distância de aceleração e desaceleração seja adaptável não só via software mas também via mudança física do projeto. Esse mecanismo permite um fácil ajuste do sensor além de permitir que o sistema seja regulado de forma fácil, tornando-o mais versátil do ponto de vista de projeto mecânico.

Outro ponto muito interessante que foi observado está nos métodos de acoplamento do sistema de redução ao equipamento de transporte. Um exemplo é o sistema de elevação de carga ilustrado na Figura 5 abaixo:

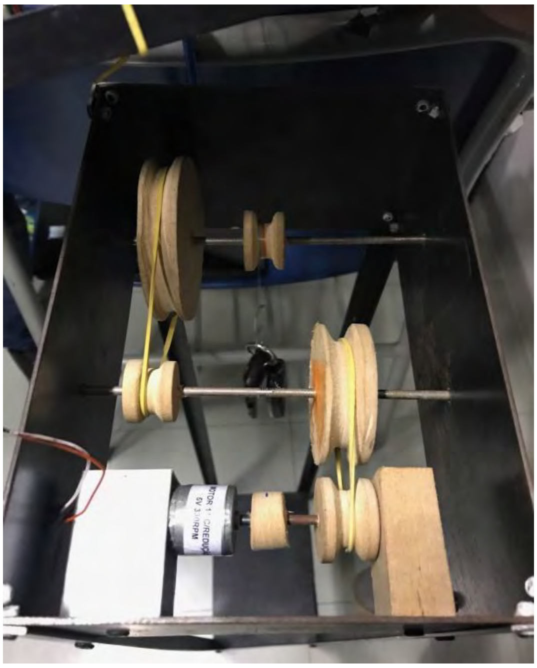

Figura 5 - Acoplamento do Sistema de Redução ao Elevador de Carga.

A solução dada pelo grupo na Figura 5 foi adicionar o tambor do cabo de sustentação diretamente ao último eixo do sistema de redução. Esse tipo de acoplamento fez com que o sistema ficasse mais compacto e pudesse ser alocado no mesmo suporte.

7 Conclusões

Depois de duas turmas já terem passado por essa atividade, notamos excelente engajamento e participação dos alunos (Weenk, 2012). A criatividade também esteve presente em boa parte dos grupos. Alguns ajustes são necessários no que tange ao cálculo e construção dos sistemas de redução, na programação do Arduino e, principalmente na compreensão do funcionamento do motor e no dimensionamento do torque necessário para a movimentação da carga, visto que este último tem sido resolvido de modo intuitivo por parte dos alunos, sem um embasamento científico.

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“Intelligent” Technology in the support of the Educational Engineering Process

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Abstract

Educational processes in areas of knowledge that require adequate prior training are becoming a challenge to the education of those who continue their studies up to the undergraduate level. Educational attitudes are promoting students to next school stages without a minimum qualifying in relevant subjects to their future choices. The Engineering area has also faced this challenge and sought support in learning methodologies associated to interactive technologies that provide continuous assistance to the learning situation of each student. In order to overcome this challenge, a type of educational software, classified as Intelligent Tutor System (ITS), has been used in the teaching-learning of courses taught in a Software Engineering course and achieved satisfactory results in relation to the student learning personalized monitoring, improving the student autonomy and enabling pedagogical actions supported by real time information about the cognitive state of each learner. ITS’s employ Artificial Intelligence techniques to create an interactive and enjoyable environment that respects the different learners cognitive styles and combines their technological resources with the educational methodologies needs. Modern ITS’s provide meaningful assistance to the key participants in the educational process (students and teachers) and guide learners in the actions they can take to improve their learning on specific contents, taking into account inferences about each learner's behaviour and outcomes during its studies. In experiments conducted in a discipline common to five engineering courses (Aerospace, Automotive, Electronics, Energy and Software), which works on the evolution of their students' logical and intellectual capabilities to solve problems, the achieved results with the use of a ITS have been satisfactory, promoting an improvement of the educational process quality and supporting students for addressing shortcomings of their previous study moments.

Keywords: Intelligent Tutoring System; Meaningful Learning; Personalized Education.

Tecnologia "Inteligente" no apoio ao Processo Educacional em Engenharia

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Resumo

Os processos educacionais em áreas de conhecimento que demandam de uma formação prévia adequada estão se tornando um desafio à educação dos estudantes que prosseguem seus estudos até o nível de graduação. Posturas educacionais estão promovendo estudantes às etapas escolares seguintes sem uma qualificação mínima condizente em assuntos relevantes às suas futuras escolhas. A área da Engenharia também tem enfrentado esse desafio e buscado apoio em metodologias de aprendizagem e tecnologias interativas que forneçam assistência contínua à situação de aprendizagem de cada estudante. Na superação desse desafio um tipo de software educacional, classificado como Sistema Tutor Inteligente (STI), tem sido empregado no ensino-aprendizagem de disciplinas lecionadas no curso de Engenharia de Software e alcançado resultados satisfatórios em relação ao acompanhamento personalizado da aprendizagem dos estudantes, melhorando a autonomia discente e possibilitando ações pedagógicas suportadas por informações em tempo real sobre o estado cognitivo de cada aprendiz. Os STIs empregam técnicas provenientes da Inteligência Artificial para criar um ambiente interativo e agradável, que respeite os diversos estilos cognitivos dos aprendizes e combine seus recursos tecnológicos com as necessidades oriundas de metodologias educacionais. Os STIs mais modernos fornecem assistência significativa aos principais participantes do processo educacional (discentes e docentes) e orientam os aprendizes nas ações que podem realizar para melhorar sua aprendizagem em conteúdos específicos, levando em conta inferências sobre o comportamento de cada aprendiz e seus resultados durante os estudos. Em experimentos realizados em uma disciplina comum a cinco cursos de engenharia (Aeroespacial, Automotiva, Eletrônica, de Energia e de Software), que trabalha a evolução das habilidades lógicas e intelectuais de seus estudantes para a solução de problemas, os resultados alcançados com o uso de um STI têm sido satisfatórios, promovendo uma melhoria da qualidade do processo educacional e apoiando os estudantes na resolução de deficiências provenientes de momentos de estudo anteriores.

Palavras-chave: Sistema Tutor Inteligente; Aprendizagem Significativa; Educação Personalizada.

1 Introdução

A expectativa da sociedade atual quanto a formação de seus futuros profissionais vem mudando a algumas décadas, podendo ser observada a demanda existente anteriormente, que exigia habilidades de memorização e identificação para se trabalhar em processos em série estabelecidos pelas fábricas. Porém, isso se modificou e essa sociedade passou a ter uma expectativa por profissionais criativos, flexíveis e facilmente adaptados para as constantes mudanças que ocorrem mais habitualmente.

No entanto, algumas deficiências básicas, provenientes dos níveis escolares anteriores ao ensino superior, estão transformando o processo educacional superior para suprir suas próprias necessidades à aprendizagem e evolução intelectual de seus novos estudantes, além de buscar a autonomia individual, intrinsecamente ligada aos aspectos do coletivo, e a capacidade de obter uma visão mais ampla do todo, a fim de conhecer melhor o problema e alcançar uma solução que atenda as necessidades particulares de cada indivíduo e das coletivas demandadas pela sociedade.

Essa transformação também tem promovido mudanças nos processos educacionais na área da Engenharia, que tem buscado apoio em metodologias de aprendizagem combinadas com tecnologias interativas capazes de fornecer assistência contínua à situação de aprendizagem de cada estudante aos principais envolvidos nesse processo (discentes e docentes). Essas tecnologias têm potencializado métodos tradicionais de ensino e colaborado com o surgimento de novas metodologias educacionais (Silva, Silva Júnior & Rissoli, 2013).

Diferentes recursos tecnológicos têm sido usados para promover a formação adequada na Engenharia, sendo destacado, neste trabalho, a utilização do software educacional classificado como Sistema Tutor Inteligente (STI) e empregado como recurso de apoio ao ensino-aprendizagem em Lógica de Programação para a solução de problemas. Essa proposta multidisciplinar almeja capacitar estudantes a resolverem problemas do mundo real, integrando nas suas soluções a elaboração de planos e projetos possíveis de serem realizados, além do desenvolvimento de funcionalidades e lógicas que poderão se tornar até programas computacionais, pertinentes a solução almejada.

Este artigo apresenta a combinação da metodologia de aprendizagem baseada nos princípios da Teoria da Aprendizagem Significativa (Ausubel, Novak & Hanesian, 1968), com a tecnologia do STI denominado SAE (Sistema de Apoio Educacional), que realiza a modelagem cognitiva de cada aluno, por meio dos construtos oriundos da Lógica *Fuzzy* (Zadeh, 1979). Essa combinação é aplicada experimentalmente em uma turma de estudantes de engenharia na disciplina Computação Básica (CB) e obtém resultados promissores.

2 Desafio Educacional

O estudo da Lógica de Programação é essencial para a evolução intelectual dos estudantes que resolverão problemas continuamente em suas futuras carreiras. Geralmente, esse estudo é iniciado a partir de problemas mais simples que promoverão reflexões lógicas que fundamentarão o estabelecimento de um raciocínio lógico coerente para resolução do problema proposto.

Assim, a elaboração de algoritmos estruturados colabora com esse momento de estudo para a solução de problemas pertinentes à Engenharia e diversas outras áreas, sendo essencial um conhecimento mínimo em disciplinas básicas trabalhadas em níveis escolares anteriores ao ensino superior.

Reconhecendo a fragilidade na formação básica nacional, normalmente, as instituições de ensino superior têm oferecido mecanismos para os estudantes superarem as deficiências ignoradas em sua formação básica, solicitando, de todos os envolvidos no processo de ensino, maior esforço e dedicação para recuperação mínima necessária à continuidade da aprendizagem desses estudantes.

As diversas áreas de conhecimento que demandam do estudo da Lógica de Programação a reconhecem como uma das mais difíceis na formação de seus estudantes, obtendo, geralmente, altos índices de reprovação na própria disciplina e naquelas que necessitam de seus conhecimentos como pré-requisito para uma aprendizagem mínima satisfatória (Delgado, Xexeo, Souza, Campos & Rapkiewicz, 2004).

Diante dessa realidade, a combinação de metodologias e tecnologias educacionais que privilegiam um processo ativo e sob a medida de cada aprendiz é necessário ao estudo da Lógica de Programação. Dessa forma, a proposta do projeto SAE, disponível no Portal do Software Público Brasileiro (PSPB, 2017), foi analisada e atendeu as características existentes para superar o desafio de lecionar o conteúdo de Lógica de Programação aos alunos de cinco cursos diferentes de engenharia (Aeroespacial, Automotiva, Eletrônica, de Energia e de Software), estando todos juntos na mesma disciplina denominada Computação Básica (disciplina classificada como de "troco comum" dessas cinco engenharias).

3 Sistema de Apoio Educacional (SAE)

O STI é um tipo de software educacional baseado em conhecimento que procura adequar estratégias de ensino às necessidades momentâneas de aprendizagem apropriada para cada estudante que o utiliza como recurso de apoio educacional. Sua arquitetura é modular e emprega técnicas de Inteligência Artificial na elaboração de um ambiente de interação adequado aos diversos estilos e situações cognitivas detectadas por seus processos de inferência (Giraffa, 1999).

A dinâmica combinação entre os dados provenientes das ações de cada aprendiz sobre todos os conteúdos ou domínios de estudo possibilitam análises do STI, que serão condizentes com a metodologia adotada pelo docente para identificação da postura pedagógica que será assumida pelo sistema, a fim de fornecer orientação adequada à realização eficiente do processo educacional específico que estará mais sintonizado a realidade de cada aprendiz.

A proposta inicial da arquitetura do STI de Carbonell (1970) agia somente na perspectiva do ensino do aprendiz. Sua concepção era de um software educacional que atuava como um tutor artificial preocupado com o ensino individualizado de cada estudante.

No entanto, os STIs mais modernos ampliaram suas possibilidades educacionais, anteriormente focadas somente no ensino, passando a armazenar dados relevantes ao acompanhamento da aprendizagem de cada estudante em particular. Assim, este tipo de software educacional deixou de ser um mecanismo de apoio específico ao estudante e tornou-se um recurso de suporte relevante ao processo educacional que assiste cada aprendiz individualmente e procura promover o seu processo de aprendizagem idiossincrático.

As responsabilidades interativas dos modernos STIs estendem suas possibilidades e o transformam em um assistente virtual de ensino inteligente para o processo educacional personalizado. Uma classificação é proposta por Yacef (2002), reconhecendo as diferentes características existentes nesses novos softwares que são chamados de *Intelligent Teaching Assistant* (ITA).

Esse assistente inteligente é um STI que também inclui o professor como seu usuário. Este novo perfil de usuário do STI/ITA colabora na orientação dos discentes e fornece em contrapartida para os docentes a assistência coerente para a sua atuação educacional, podendo observar, com mais detalhes, o comportamento de cada estudante em atividades realizadas em aula ou em períodos extraclasse.

Uma representação dos módulos existentes na arquitetura do STI/ITA pode ser observada na figura 1, em que os módulos específicos, implementados no projeto SAE, estão destacados, a fim de indicar as extensões disponíveis neste ITA que foi utilizado como recurso de suporte nas atividades letivas que almejavam a aprendizagem dos conteúdos de Lógica de Programação na disciplina CB.

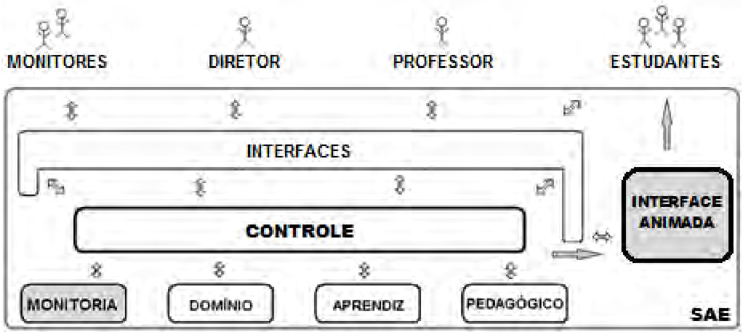

Figura 44. Representação da arquitetura modular do STI/ITA, em que são destacados os diferentes módulos do SAE.

Os principais módulos existentes na proposta inicial dos STIs estão presentes no ITA (Domínio, Aprendiz, Pedagógico e Interface), conforme apresenta a figura 1. No entanto, o módulo Interface possui uma implementação mais especializada devido a sua diversificação de usuários que precisa ser atendida em suas necessidades de apoio pertinentes aos objetivos discentes e docentes no processo educacional.

No SAE ainda existem outros perfis de usuários que participam do processo educacional, de maneira direta ou indireta, e são assistidos por esse ITA. Esses outros perfis correspondem aos monitores estudantis (alunos mais experientes) e os diretores ou coordenadores de curso que possuem uma interface adequada as suas atividades e responsabilidades a serem executadas no âmbito do ensino-aprendizagem.

Além dessa interface de comunicação apropriada entre os diferentes perfis de usuário do ITA, o módulo de Controle do STI tradicional também é expandido em sua implementação para atender as novas responsabilidades de assistência educacional que são coerentes a cada um desses perfis, colaboradores do processo, e que demanda de diferentes necessidades relativas a melhoria do ensino-aprendizagem.

Como o módulo de Controle funciona como articulador e coordenador que garante o sincronismo entre os demais módulos, a fim de fornecer a assistência adequada para cada perfil de usuário do SAE, suas apurações e análises estão relacionadas a interação de cada um destes perfis com o sistema, que por sua vez provê em contrapartida a assistência condizente com as necessidades particulares de cada perfil, a fim de estabelecer um processo mais seguro e de qualidade na aprendizagem de seus principais usuários (aprendizes).

A arquitetura mostrada na figura 1 possui o módulo Domínio que fornece os recursos disponíveis ao armazenamento seguro dos conteúdos que serão abordados durante o ensino-aprendizagem. Esses conteúdos estão organizados de maneira coerente com a abordagem didático-pedagógica que os explorará, além de empregarem algum tipo de formalismo proveniente da Inteligência Artificial.

A situação de aprendizagem de cada estudante usuário desse ITA é representada no módulo Aprendiz da figura 1, sendo este módulo responsável pelo fornecimento de subsídios relevantes ao acompanhamento pertinente da situação de aprendizagem atual de cada estudante. A modelagem dos aspectos cognitivos de cada aprendiz em relação a cada item de estudo previamente organizado no módulo Domínio é averiguado e armazenado no módulo Aprendiz.

O módulo Pedagógico oferece as formas de interação que o SAE poderá trabalhar com cada estudante, conforme a situação de aprendizagem apurada e a metodologia educacional adotada pelo docente. O módulo Controle, indicado na figura 1, manipula, independentemente, os dados contidos nesses outros módulos e infere a situação cognitiva de cada estudante, assim como a ação a ser realizada pelo SAE em conformidade com a metodologia adotada e o perfil de usuário que está conectado com o sistema.

A interface desse assistente inteligente aplica os recursos tecnológicos mais coerentes para realização de uma interação segura e intuitiva aos seus diferentes tipos de usuário, procurando promover a tutoria mais adequada e agradável aos objetivos do estudante e a assistência ágil e sintonizada as responsabilidades docentes de acompanhamento e orientação pedagógica, além da colaboração dos monitores e diretores de curso.

O aporte tecnológico é importante ao processo educacional, mas fundamental ao seu sucesso é a adoção da metodologia educacional adequada aos objetivos do conteúdo letivo, geralmente, organizado em disciplinas que compõem, estrategicamente, um projeto pedagógico maior em cursos de nível superior.

Diante da realidade investigada, e o reconhecimento dos desafios a serem superados no ensino de Lógica de Programação, a proposta de Ausubel, Novak e Hanesian (1968), conhecida como Teoria da Aprendizagem Significativa (TAS), se destaca por trabalhar o processo educacional sintonizado a realidade cognitiva de cada aprendiz.

A TAS procura promover a aprendizagem facilitada por meio da associação dos novos conceitos, a serem assimilados pelo estudante, aos conhecimentos já existentes em sua estrutura cognitiva. Esses conhecimentos já estabelecidos são definidos como conceitos subsunçores e podem ser aplicados a qualquer área do conhecimento humano como recurso empregado na colaboração da construção de novos conhecimentos ou na consolidação de conhecimentos que estão se estabelecendo na estrutura cognitiva dos estudantes.

Com base nessa teoria (TAS) são empregadas estratégias mais centradas na aprendizagem do que no ensino, privilegiando a formação do aprendiz autônomo que pensa, pesquisa e inova usando de suas próprias habilidades sociais e intelectuais disponíveis em seu desenvolvimento cognitivo.

A técnica conhecida como Mapa Conceitual (MC) é proveniente dos pressupostos da TAS e fornece uma representação de fácil compreensão e manipulação das estruturas conceituais envolvidas na organização hierárquica de um conteúdo letivo, concedendo uma visão integrada entre esses conceitos, além do respeito às hipóteses fundamentais da TAS (Novak, 1998).

Geralmente, a elaboração do MC é efetuada por especialistas responsáveis pelo ensino-aprendizagem de determinado conteúdo, sendo nele representada a expectativa da aprendizagem dos estudantes. A composição adequada do MC promove a organização dos conteúdos que facilitam a identificação de pré-requisitos e correquisitos, sendo esses fundamentais na organização do módulo Domínio do SAE para o acompanhamento personalizado da situação da aprendizagem de cada estudante, fornecendo-lhe orientação pedagógica adequada ao seu estado cognitivo detectado em tempo real.

A efetivação desse tipo de acompanhamento e orientação confere ao SAE aspectos de inteligência, especialmente, pelo tratamento mais realista, e matematicamente adequado, das incertezas e imprecisões inerentes a este tipo de informação, que é efetuado pela Lógica *Fuzzy* nesse ITA. A integração de tecnologias que propiciam a realização de operações anteriormente possíveis somente aos seres humanos tem alcançado resultados satisfatórios na área da Educação, principalmente, quando inseridas de maneira colaborativa com a atuação dos agentes humanos (Silva, Silva Júnior & Rissoli, 2013).

A aplicação da Lógica *Fuzzy*, aliada a TAS, almeja detectar comportamentos observáveis do estudante sobre o conteúdo e as atividades de sua aprendizagem durante os seus diferentes períodos de estudo. A Inteligência Artificial utiliza essa lógica buscando simular o raciocínio humano, usando seu potencial de representação linguística, com forte amparo matemático, para descrever melhor a realidade analisada.

Algumas variáveis relacionadas ao comportamento observável dos estudantes são capturadas durante as interações destes com o ambiente SAE, sendo seus dados provenientes dos registros de acesso e dos resultados obtidos nas opções oferecidas pelo assistente e escolhidas pelos estudantes durante essas interações. Outras informações armazenadas pelo SAE são originárias de momentos interativos dos estudantes com os agentes humanos que participam do processo educacional. Essas informações, e dados do assistente virtual, são integrados no módulo Aprendiz e se constituem na parte significativa do conhecimento do assistente sobre cada aprendiz (construção do modelo de aluno), tornando-se responsáveis pela formação da Base de Conhecimento (BC) que o sistema utiliza na apuração do esforço e dos resultados alcançados pelos estudantes no decorrer de cada processo educacional.

Os processos de inferência realizados pelo SAE acontecem sobre esta BC, que emprega a Lógica *Fuzzy* para "raciocinar" sobre a situação de aprendizagem de cada estudante e orientá-lo no avanço pertinente a sua evolução no estudo de cada conteúdo. O motor dessa inferência é baseado no MC que propõe a organização dos conceitos explorados por conteúdo (ou disciplina). Esse motor de inferência usa regras de produção, variáveis e termos linguísticos, além de funções de pertinência condizentes com os aspectos definidos por seus docentes e especialistas.

A combinação da Lógica *Fuzzy* com os Mapas Conceituas promove a inovação nas formas de acompanhamento tradicionais da TAS, possibilitando a averiguação da situação da aprendizagem de cada estudante em conceitos específicos contidos no MC. Com base na Teoria dos Conjuntos *Fuzzy* esses conceitos se tornarão elementos de um conjunto *fuzzy* responsável pelo acompanhamento da situação da aprendizagem de cada estudante usuário do SAE.

Várias pesquisas têm investigado a contribuição da Lógica *Fuzzy* em processos educacionais, sendo destacado nesse trabalho a pesquisa de Malvezzi, Mourão e Bressan (2010) que considera que o uso dessa lógica lhes possibilitou "materializar algo tão abstrato que é o nível de evolução da aprendizagem do estudante".

Diante do desafio de lecionar a disciplina CB para estudantes de diferentes cursos de engenharia, foram definidos os conceitos relevantes de Lógica de Programação que estariam inseridos no MC dessa disciplina, respeitando ainda os objetivos previstos em seu Plano de Ensino.

4 Experimento e Resultados

Com o objetivo de verificar essa proposta integrativa (TAS com Fuzzy) foi realizado um experimento envolvendo uma turma da disciplina de CB em uma instituição de ensino superior brasileira. Neste experimento foram usadas três variáveis linguísticas associadas aos comportamentos observáveis dos aprendizes e relevantes para averiguação de sua aprendizagem significativa (transforma os conceitos previstos no MC em significados psicológicos estabelecidos na estrutura cognitiva do aprendiz). Estas variáveis foram **esforço** (quantidade e recurso do ambiente usado pelo aprendiz), **desempenho** (resultados obtidos na interação com o SAE) e **acompanhamento real** (avaliação realizada pelo docente sobre as atividades avaliativas previstas no plano de ensino da disciplina). Por meio dessas variáveis o SAE inferi a assimilação de cada estudante que conseguiu transformar o significado lógico, inerente ao conteúdo de estudo, em significado psicológico, evidenciando a aquisição de conceitos na estrutura cognitiva do estudante (Moreira & Masini, 1982).

A definição das funções de pertinência associadas aos termos linguísticos condizentes com cada uma dessas variáveis linguísticas permite a identificação mais realista da situação cognitiva de aprendizagem de cada estudante sobre os conceitos que compõem o MC elaborado. Isso ocorre por meio da identificação do grau de pertinência dos resultados obtidos em cada conceito, sendo estes elementos reunidos no conjunto *fuzzy* que representa a aprendizagem de cada estudante.

Cada um dos elementos deste conjunto *fuzzy* é definido a partir do MC, sendo decididos seus cortes mínimos essenciais para o prosseguimento no estudo do conceito subsequente. Com base nestes resultados, o ambiente do SAE oferece recursos e orientações coerentes ao caminho de aprendizagem mais eficiente para cada aprendiz durante seu processo de assimilação, sendo o docente e o assistente inteligente (SAE) responsáveis pelo direcionamento adequado desse processo educacional.

Diante disso, as funções de pertinência das variáveis linguísticas de **esforço** (V), **desempenho** (U) e **acompanhamento real** (R) vão sendo aplicadas sobre cada um dos conceitos estudados, almejando efetuar o acompanhamento individual de cada aprendiz pelo SAE. Os respectivos termos linguísticos correspondentes a estas três variáveis são: T(V) = {baixo, médio, alto}, T(U) = {fraco, razoável, bom} e T(R) {aprovado, bem, intermediário, mal}.

Os valores desses termos são obtidos pelas respectivas funções de pertinência, que atribuem a cada termo o seu grau de pertinência correspondente. A operação de máximo, caracterizada na Teoria dos Conjuntos Fuzzy como uma *S-norma* (Nicolleti & Camargo, 2004), é aplicada em cada uma das variáveis linguísticas e atribui a estas o termo linguístico mais significativo que foi apurado pelo SAE.

A partir dessas atribuições para as três variáveis linguísticas o processamento do SAE utiliza proposições condicionais não qualificadas (SE... ENTÃO) na realização de sua inferência fuzzy. Isso confere "inteligência" nas apurações realizadas pelo SAE e na orientação fornecida aos estudantes sobre quais atividades interativas realizar e sobre qual conteúdo dedicar maior atenção em seus estudos atuais.

Com o apoio desse assistente inteligente e a mediação docente, cada aprendiz poderá obter resultados satisfatórios na assimilação de cada conceito previsto no MC. Assim, cada elemento do conjunto *fuzzy* poderá atingir uma situação de aprendizagem mínima satisfatória aos objetivos do conteúdo letivo (disciplina), sendo possível, somente para essa situação de aprendizagem acompanhada pelo SAE, ser mensurado um resultado único sobre a aprendizagem ter sido significativa para qualquer estudante que consiga atingir tal situação. A obtenção desse resultado *fuzzy* corresponde a ponderação alcançada pelos graus de pertinência atribuídos a cada elemento pertencente ao conjunto *fuzzy* do conteúdo em estudo. Essa ponderação é calculada pelo Grau de Disparo do conjunto *fuzzy* e fornece um valor de confiança do assistente inteligente sobre a aprendizagem de cada estudante ter sido significativa, enquanto foi assistida pelo SAE (Klir & Yuan, 1995).

4.1 Resultados

A utilização experimental dessa proposta aconteceu sobre uma das turmas da disciplina de CB no segundo semestre de 2016 e envolveu 58 alunos matriculados inicialmente nesta turma, 5 monitores da disciplina e 1 docente responsável pela condução da turma, além de alguns especialistas da área de Engenharia, Educação e Informática na Educação.

O acompanhamento do processo educacional foi realizado de maneira contínua pelo docente e os monitores da disciplina através dos encontros presenciais e das tecnologias envolvidas nas atividades dessa turma. Após o encerramento das atividades previstas no plano de ensino de CB seus alunos foram convidados a participar de uma pesquisa de opinião sobre as características da disciplina/turma e seus recursos de apoio ao processo educacional. Trinta e três desses alunos (56,9% dos matriculados inicialmente) participaram e todos eles indicaram aspectos positivos quanto aos recursos e as tecnologias utilizadas pela disciplina, como pode ser observado em alguns de seus relatos transcritos a seguir:

> "*Pude ter maior apoio educacional mesmo não estando na faculdade, podendo tirar dúvidas, responder questionários e ter um feedback do nível do meu ensino quase em tempo real.*"
>
> "*Indicaram onde eu estava com mais dificuldade e forneceram materiais para estudo.*"
>
> "[...] *foram importantes para mim porque foram meios onde eu pude sozinho buscar entender a matéria e encontrar meus erros e corrigi-los, sendo um auxílio além da monitoria e as aulas ministradas pelo*

professor. Ou seja, foram meios que me auxiliaram na busca de tentar entender e ver onde eu estava errando e melhorar buscando sempre alcançar o nível que a disciplina se encontrava."

A relevância da monitoria como recurso de apoio na aprendizagem de Lógica de Programação em CB foi confirmada por 29 desses alunos (quase 88% dos participantes), no qual 27 informaram que visitaram a monitoria em períodos extraclasse (81,8%) durante o semestre letivo. Vários desses alunos relatam que foram visitar a monitoria após receberem a orientação do SAE sobre algum conteúdo que estavam estudando.

Dentre todos os alunos que participaram dessa pesquisa 28 asseveram que seguiram orientações fornecidas pelo SAE (84,8%). Somente um aluno, entre os participantes, classificou a sua própria participação na disciplina como sendo fraca, ou seja, 32 alunos (praticamente 97%) reconhecem que participaram ativamente da disciplina (8 classificam a própria participação como ótima e 24 como boa).

Um dado relevante como indicativo dessa participação ativa é a classificação que todos os alunos que responderam a essa pesquisa (33) fizeram sobre a participação de seus colegas de turma (7 classificaram como ótima a participação dos colegas e 26 como boa). Questionados pela pesquisa se a disciplina teria atendido suas expectativas iniciais, 29 alunos disseram que sim (87,8%), no qual 28 ainda afirmam que indicariam a outros colegas cursarem essa disciplina na forma em que está organizada (praticamente 85%). Algumas dessas afirmações estão transcritas a seguir como depoimentos dos estudantes que passaram por este experimento:

"*Indicaria esta disciplina pela melhoria no raciocínio lógico e pela noção básica que ela traz sobre computação, aspectos fundamentais nas áreas da engenharia no geral* [...]"

"*Pois é uma disciplina que te apresenta, para muitos que ainda não viram, um pouco do mundo da programação, que independente da área, da engenharia que o aluno for seguir, é uma matéria muito importante, e com os recursos utilizados pelo professor, se tornou algo que mudou minha noção sobre esse mundo*."

"*Porque utilizando esses recursos o aluno é obrigado a aprender, para quem não possui motivação para estudar sozinho como eu. Os recursos utilizados são um grande incentivo*."

"*A aprendizagem de resolução de problemas oferecida pela disciplina é fundamental, não apenas para a área de Computação, mas também para a engenharia como um todo. Muito tempo é economizado ao se pensar bastante para resolver um problema, sendo a parte de "programar", fazer cálculos ou "botar a mão na massa" a parte menos complicada quando se tem uma lógica bem desenvolvida para resolver situações*."

"*Pois esses recursos facilitam a aprendizagem e motivam o aluno a estudar para obter um satisfatório nos conteúdos*."

O docente responsável pela turma ressalta que estes recursos propiciam maior autonomia aos alunos e, consequentemente, promovem a evolução de algumas de suas habilidades. No entanto, vários são os estudantes que não estão preparados para isso e sentem dificuldade em lhe dar com a própria autonomia no âmbito da Educação. Com o objetivo de ampará-los, e promover uma educação personalizada e de qualidade, os agentes humanos (docente e monitores) também recebem assistência do SAE para agirem em coerência com as possíveis dificuldades de cada aprendiz.

Dessa forma, a postura desses agentes estará melhor subsidiada pelas informações compartilhadas pelo SAE e contribuirá com as ações do docente e dos monitores no apoio adequado a ser oferecido aos aprendizes.

5 Considerações Finais e Trabalhos Futuros

A utilização dos recursos oferecidos pelo Sistema de Apoio Educacional (SAE) na disciplina de Computação Básica (CB), que leciona Lógica de Programação em diferentes cursos de Engenharia, alcançou resultados satisfatórios às expectativas dos principais envolvidos em seu processo educacional (discentes e docente), além de melhorar os índices de aprovação dos estudantes que cursam esta disciplina na instituição de ensino onde o experimento foi efetuado. Os índices de aprovação obtidos nesse experimento foram de pouco mais de 82% (32 alunos), enquanto que a reprovação se aproximou de 18% (7 alunos).

Como a turma iniciou o semestre letivo com 58 alunos matriculados, torna-se importante esclarecer como foram retirados os "ruídos" presentes neste experimento. Esses "ruídos" correspondem aos alunos matriculados inicialmente na disciplina, mas que não chegaram a realizar suas principais atividades avaliativas (15 alunos oficialmente trancaram a matrícula no período permitido pela instituição) ou que possuíam ausência bem superior ao tolerado pela educação nacional (2 alunos nunca frequentaram a disciplina e outros 2 tiveram ausência superior a 70%).

A principal contribuição deste trabalho consiste em mostrar que a combinação dos recursos humanos e as tecnologias "inteligentes", aplicadas na educação, oferecem um espaço de aprendizagem dinâmico, com assistência baseada no acompanhamento mais realista de cada estudante, estimulando a autonomia do aprendiz, com o fornecimento de apoio contínuo que propicia o desenvolvimento de suas habilidades sociais e intelectuais, inclusive, sobre as deficiências provenientes de níveis anteriores de estudo.

Esse tipo de apoio incentiva a autonomia do aprendiz e contribui com sua motivação, engajamento, desempenho em atividades avaliativas e em estados psicológicos que promovem o bem-estar e a satisfação com a vida, além do próprio desenvolvimento evidenciando a autoestima e a criatividade (Reeve, 2009).

Apesar dos resultados positivos, é relevante notar que a evasão foi expressiva, tendo 19 alunos (32,7% dos matriculados inicialmente) abandonado a disciplina em algum momento. Essa realidade pode ser observada em disciplinas que lecionam Lógica de Programação. No entanto, as possibilidades de assistência disponíveis no SAE poderiam também contemplar análises sobre o risco de evasão de qualquer aluno em tempo real e ainda colaborar mais com a efetivação de um processo educacional de qualidade e atento às particularidades de cada aprendiz.

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Pedagogical Architectures for Active Learning

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Abstract

The Digital culture has provided a favorable environment to migration from transmissive education to active learning. The possibility of the integrated use of different media, the possibilities of communication and the cooperative creation of artefacts, both in digital media and tangibles medias, allows the conception of a school that overflows the notions of times and spaces present in the conventional school where the walls and the clock restrict the pedagogical conceptions. However, the introduction of digital elements in the design of environments and tools to support the transformation of pedagogical practices is still populated by fragmented solutions, characterized by the simple addition of new technological resources to educational processes conceived within instructional paradigms. Seeking to contribute to overcome this fragmentation we propose an approach of integration of the technologies to the processes of learning based on the cognitive ecology that we define as pedagogical architectures. The Pedagogical Architectures are conceived as learning structures made from the confluence of different components: active pedagogical approach, digital technology (software, internet, artificial intelligence and others), and a flexible conception of time and space. The Pedagogical Architectures are characterized by the following elements: a) a domain of knowledge to be investigated; b) the previous knowledge of the students on this domain; c) dynamics for individual and cooperative production of artifacts to support the reflections on the area under investigation; d) distributed pedagogical mediations and, e) process and cooperative evaluation of learning. In our teaching work we have conceived and experimented with several architectures such as Theses Debate, Learning Projects, Collective Stories, Design of Physical Spaces, Construction of Digital Games and Computer Programming. In this paper we presents the theoretical and methodological foundation, examples of the use of architectures and we argue in favor of its adequacy to support active learning, both in engineering education as in computer science education.

Keywords: Pedagogical Architectures; Active Learning; Ecosystems for Learning.

Arquiteturas Pedagógicas para Aprendizagem Ativa

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Resumo

A cultura digital tem propiciado um ambiente favorável à migração da educação transmissiva para a aprendizagem ativa. A possibilidade do uso integrado de diferentes mídias, as possibilidades de comunicação e criação cooperativa de artefatos, digitais ou não, viabiliza a concepção de uma escola que transborda as noções de tempos e espaços presentes na escola convencional onde as paredes e o relógio restringem as concepções pedagógicas. No entanto, a introdução de elementos digitais na concepção de ambientes e ferramentas para apoiar a transformação das práticas pedagógicas ainda é povoada por soluções fragmentadas, caracterizadas pela simples soma de novos recursos tecnológicos a processos educacionais concebidos dentro de paradigmas instrucionistas. Buscando contribuir para superar esta fragmentação propomos uma abordagem de integração das tecnologias aos processos de aprendizagem baseada na ecologia cognitiva que definimos como arquiteturas pedagógicas. As Arquiteturas Pedagógicas são concebidas como estruturas de aprendizagem realizadas a partir da confluência de diferentes componentes: abordagem pedagógica ativa, tecnologia digital (software, internet, inteligência artificial e outros), concepção flexível de tempo e de espaço. As Arquiteturas Pedagógicas são caracterizadas pelos seguintes elementos: a) um domínio de conhecimento a ser investigado; b) o conhecimento prévio dos estudantes sobre este domínio; c) dinâmicas para produção individual e cooperativa de artefatos para apoiar as reflexões sobre o domínio investigado; d) mediações pedagógicas distribuídas e, e) avaliação processual e cooperativa das aprendizagens. Em nossa atuação docente temos concebido e experimentado diversas arquiteturas tais como Debate de Teses, Projetos de Aprendizagem, Construção de histórias coletivas, Concepção de Espaços Físicos, Construção de Jogos Digitais e Programação de Computadores. Neste trabalho apresentamos a fundamentação teórico-metodológica, exemplos de uso de arquiteturas e argumentamos em favor da sua adequação para apoiar a aprendizagem ativa na educação em engenharia e na ciência da computação.

Keywords: Arquiteturas Pedagógicas; Aprendizagem Ativa; Ecossistemas para Aprendizagem.

1 Introdução

Estudos recentes no campo da educação sinalizam a possibilidade e a importância de considerarmos o nosso habitat levando em conta muitos outros aspectos além do determinado pelo nosso ambiente físico. Para o ser humano, outros contextos devem ser considerados tais como o das relações sociais e o da subjetividade. Podemos entender essas inciativas como um movimento filosófico que nos ajuda a pensar em diferentes campos de estudo com um suporte conceitual comum, definido a partir de seus ecossistemas. Inspirados nessa perspectiva, estudiosos da área da educação, como por exemplo, Brown (2001) e Jackson (2013) veem trabalhando na constituição de um campo de estudo que tem sido denominado de "Ecologia da Aprendizagem".

A ideia central dessas iniciativas é compreender o processo de construção de conhecimento como uma atividade complexa, onde agentes humanos interagem de forma orquestrada ou eventual e que a partir dessas interações, onde ocorrem desequilíbrios e mediações, torna-se possível atingir novos patamares de compreensão de seus objetos de estudo.

Para que ocorram essas interações é necessário dispor de linguagens e veículos de comunicação adequados, tendo em vistas que os atores podem estar dispersos geograficamente e possivelmente disponíveis em momentos diferentes. Além disso, há necessidade de ter acesso a documentos relevantes e, muitas vezes, resultam dessas interações novos produtos que precisam ser disponibilizados para os participantes diretos e para os demais interessados. Para todas essas atividades é fundamental a existência de suportes conceituais e físicos, que se constituem no que Pierre Levy (1990) denomina de tecnologias da inteligência.

Inspirados nestas concepções, temos trabalhado na construção de propostas pedagógicas, com o suporte das tecnologias digitais e fundamentados na epistemologia genética de Jean Piaget (1971; 1990). Para caracterizar a natureza diferenciada dessas propostas, optamos por denomina-las de Arquiteturas Pedagógicas (AP). Em nossa atuação docente temos concebido e experimentado diversas arquiteturas tais como Debate de Teses, Projetos de Aprendizagem, Construção de histórias coletivas, Concepção de Espaços Físicos, Construção de Jogos Digitais e Programação de Computadores.

Neste trabalho apresentamos a fundamentação teórico-metodológica desta abordagem e, como exemplo, a aplicação de uma Arquitetura Pedagógica voltada a apoiar o desenvolvimento da capacidade reflexiva de professores em serviço. Essa escolha justifica-se pelo fato da arquitetura apresentar uma dinâmica com amplo potencial de uso em diferentes contextos de formação e desenvolvimento de profissionais reflexivos, independentes de sua área de atuação.

2 Educação e cultura digital

Desde o surgimento do Computador, ao longo de 7 décadas, surgiram inúmeras iniciativas buscando a construção de ambientes e tecnologias para promoção da aprendizagem com apoio dos computadores. Essas iniciativas deram origem a diferentes linhas de pesquisa tais como sistemas colaborativos para apoio à aprendizagem, jogos aplicados à educação, inteligência artificial aplicada à educação e interação humano-computador em ambientes de aprendizagem. Durantes as três primeiras décadas da história do uso de computadores na educação os ambientes concebidos eram na maioria das vezes, hospedados em computadores isolados e usados em experimentações com indivíduos isolados ou pequenos grupos. As linguagens eram de difícil compreensão para o público não especializado, os computadores tinham baixa performance e a capacidade de armazenamento era extremamente limitada. Muitas dessas iniciativas ainda tinham como principal viés pedagógico, a transmissão do conhecimento. Apesar disso, foi neste período que surgiu a Linguagem de Programação Logo, concebida com base na epistemologia genética (Piaget, 1971) para apoiar a construção de conhecimento a partir da produção de programas que "ensinavam" máquinas a realizar novas atividades (Papert, 1980).

Até meados dos anos 90, no uso cotidiano, a utilização de computadores ainda era realizada em máquinas isoladas ou organizadas em pequenas redes locais, em laboratórios de grandes instituições de ensino. A partir da segunda metade desta década, a internet se tornou disponível para o público em geral o que deu origem a uma nova forma de conviver em sociedade a partir do uso intenso dessa máquina também como instrumento de comunicação.

O surgimento da web 2.0, no final do século 20, consolidou de vez o uso da internet em interações sociais e na produção de conteúdo por milhões de cidadãos que passaram a agir em grupos, em um nível elevado de trocas, produzindo novos conteúdos para Internet e participando intensamente de interações sociais usando os ambientes denominados de redes sociais.

Nas escolas, o uso das tecnologias digitais ainda tinha como restrição a mobilidade, dado que computadores desktop e mesmo notebooks apresentam inconvenientes a esse respeito. Com a chegada dos smartphones e tablets esta barreira foi rompida viabilizando assim que uma quantidade crescente de pessoas estejam continuamente conectada à qualquer hora e em qualquer lugar.

No contexto escolar, o desafio que hoje temos, professores e estudantes, é conceber propostas pedagógicas que façam um uso destas tecnologias para potencializar as aprendizagens.

3 Fundamentação Teórica

A concepção de escola que ainda prepondera nos dias de hoje está apoiada em tecnologias da inteligência que dificultam as interações (Levy, 1990). Nesse cenário, o centro do modelo é o professor, de onde emana o conhecimento. Este modelo é justificado por teorias comportamentalistas da aprendizagem. Segundo Freire (1978), nesse "modelo bancário" o professor transfere conhecimentos para os estudantes e, em determinadas datas, realiza uma prova para conferir se o que foi depositado foi de fato memorizado por seus alunos.

Pesquisas mais recentes (Jackson, 2013) apontam para a necessidade de incorporar a escola ao seu contexto, abandonado a hipótese de tratá-la como um sistema fechado. As aprendizagens transbordam as fronteiras das paredes escolares e se manifestam no contexto familiar, nos grupos de amigos, no trabalho e em todos os demais agrupamentos das pessoas. Pensar o uso de tecnologias digitais para apoiar a construção de ferramentas que apoiem o trabalho escolar dentro do paradigma ainda dominante, de natureza predominantemente transmissiva, é ajudar a informatizar práticas que aceleram o fazer errado.

Apoiado na Epistemologia Genética de Jean Piaget e no Construtivismo Social de Vygotsky, os quais estão em perfeita sintonia como a visão ecológica de Baterson e outros, John Brown em seu trabalho "Growing Up Digital" (Brown, 2000), apresenta a proposta de uma "ecologia da aprendizagem". Naquele trabalho Brown apresenta vários exemplos de ambientes de aprendizagem cujas propostas são abrangentes, envolvem intensas interações entre os estudantes e os mediadores, em um processo continuado onde as avaliações buscam fundamentalmente apoiar o processo de modo a torná-lo mais adequado aos propósitos de seus participantes.

De acordo com pesquisadores do OSL (2017) uma ecologia da aprendizagem compartilha os mesmos elementos de uma ecologia no senso convencional, quais sejam:

- Um habitat onde diferentes espécies coexistem em uma relativa estabilidade e interdependência;
- Um conjunto de territórios e nichos distintos, que se interceptam. Cada um dos quais com suas próprias regras, *affordances* e restrições;
- Um sistema auto regulatório que consome e recicla recursos;
- Uma organização na qual ocorrem mudanças ao longo do tempo, modificando indivíduos, espécies e inter-relações sem destruir a coesão e o equilíbrio global.

A esses elementos, os autores sugerem que a Ecologia da Aprendizagem adiciona um elemento extremamente diferencial que é a Reflexividade Cognitiva. Através desta capacidade, os indivíduos estão continuadamente pensando e avaliando seus próprios hábitos e os hábitos coletivos, e constituem-se em um instrumento fundamental para mudanças no ecossistema.

4 Arquiteturas Pedagógicas

Buscando superar as fragmentações que tornam a Informática na Educação uma simples soma de novos recursos tecnológicos a processos educacionais concebidos dentro de paradigmas instrucionistas já amplamente difundidos, propomos uma abordagem de integração das tecnologias aos processos de aprendizagem baseada nas ecologias cognitivas e da aprendizagem, proposta pelos autores anteriormente citados Bateson (1972), Levy (1990), Brown (2000) e Jackson (2013).

A proposta foi caracterizada a partir da criação das arquiteturas pedagógicas, definidas como estruturas de aprendizagem realizadas a partir da confluência de diferentes componentes: abordagem pedagógica, software, internet, inteligência artificial, e novas concepções de tempo e espaço (Nevado. R. A.; Carvalho, M. J. S. e Menezes, C. S, 2007). As arquiteturas pedagógicas foram concebidas de forma a acolher pedagogias abertas, maleáveis e flexíveis para promover novos modos de conhecer e fomentar o pensamento em rede. Diversas arquiteturas foram propostas, como a arquitetura de debate de teses, projetos de aprendizagem e construção de histórias coletivas (Nevado, R.A; Charczuk, S.B.; Ziede, M., 2016). Estas arquiteturas têm sido usadas no desenvolvimento de diversas disciplinas do programa de mestrado em informática em uma universidade brasileira, por um dos autores,

Mais recentemente, trabalhando em um curso de formação de professores, concebemos uma arquitetura pedagógica para apoiar a aprendizagem transversal, integrando diferentes disciplinas acadêmicas de diferentes semestres, dentro da quais várias outras arquiteturas menores são integradas para potencializar as aprendizagens. É esta arquitetura que apresentamos neste artigo. As arquiteturas menores que compõe a arquitetura principal, que são descritas separadamente. Dessas arquiteturas menores, elegemos uma delas para apresentar detalhes de sua aplicação em uma situação real do curso de pedagogia citado. Sobre esta aplicação apresentamos também uma análise dos resultados.

4.1 Arquitetura Pedagógica - Compartilhamento e Avaliação de Aprendizagens

No contexto de um curso de graduação na modalidade a distância, para formação de professores em serviço, criamos e estamos consolidando uma Arquitetura Pedagógica onde se desenvolvem várias dinâmicas que perpassam todo o curso, durante os seus 9 semestres letivos. Os atores deste ecossistema de aprendizagem são os alunos-professores, os tutores e os formadores. Os tutores podem ser de uma disciplina específica (Tutores-D) ou de uma disciplina estruturante que também perpassa todo o curso, denominada Seminário Integrador (Tutores-SI). O objetivo primordial desta AP é apoiar o desenvolvimento intelectual dos cursistas, para que, constituam-se em professores reflexivos.

Esta AP está organizada a partir de uma arquitetura principal à qual fomos acrescentando novas arquiteturas para favorecer o desenvolvimento do professor reflexivo.

Contexto: A cada semestre os alunos estão envolvidos com diferentes interdisciplinas nas quais desenvolvem atividades práticas e teóricas relacionadas com o seu trabalho em suas salas de aulas.

Dinâmica Básica: Cada aluno é incentivado a registrar em um portfólio individual as suas aprendizagens marcantes, com a sugestão de que busquem registrar pelo menos uma postagem por semana. As postagens são de natureza hipermidiática podendo conter textos, imagens e vídeos e podem ainda estar ligadas a outras postagens ou sites da Internet. Esses registros originam-se na percepção de que algo novo está ocorrendo na sua forma de agir/pensar/planejar/interagir no seu trabalho, nos seus estudos e nas suas relações pessoais. A ideia é indicar a mudança percebida e buscar estabelecer uma relação entre a mudança e um aporte teórico, independente do momento do curso onde este aporte lhe foi apresentado ou até mesmo se veio a partir do curso ou se teve origem em iniciativas pessoais de busca de novos conteúdos.

Mediação: Os Tutores-SI trabalham com cerca de 20 alunos e, semanalmente visitam todas as postagens analisando e dando feedback, questionando e solicitando melhorias na argumentação. Os Tutores-D das diversas disciplinas analisam as postagens que se relacionam com as disciplinas nas quais trabalham e comentam sugerindo melhorias, pedindo esclarecimentos e recomendando aprofundamentos.

4.1.1 Arquitetura Pedagógica 2: Revisão por Pares

Contexto: As postagens ficam disponíveis para o acesso de todos os participantes e assim, todos os colegas são convidados a voluntariamente visitar e comentar, pedir esclarecimento e/ou traçar paralelo com situações similares que já vivenciou.
Dinâmica: além das visitas voluntárias periodicamente, os alunos são convidados e visitar e comentar o portfólio de um ou mais colegas. Este movimento tem várias possibilidades de enriquecimento das aprendizagens. Um dele é apoiar a construção do pensamento crítico, dado que cada um precisará olhar para uma ou mais modos de escrever e compreender os relatos de aprendizagens originadas em outros contextos.

Mediação: Professores e tutores leem e discutem com os alunos-revisores os tipos de comentários que estão sendo utilizados.

4.1.2 Arquitetura Pedagógica 3: Avaliação das Aprendizagens de um semestre (Workshop de Avaliação Integrada)

Contexto: Ao final de cada semestre as postagens registradas nos portfólios individuais são retomadas para apoiar a avaliação Integrada

Dinâmica: os alunos são convidados a construir um documento de avaliação denominado Síntese Reflexiva das Aprendizagens. O documento deve fazer referências às postagens para dar sustentação à síntese e adicionalmente é solicitado que seja escolhida uma ou mais postagens como sendo destaque nas suas aprendizagens do semestre. Este documento é revisado por tutores e professores e dão origem a uma apresentação oral para uma banca formada por até 10 colegas um tutor e um professor. O resultado deste workshop compõe a atribuição de conceitos nas diversas interdisciplinas do semestre.

4.1.3 Arquitetura Pedagógica 3: Estabelecendo Critérios para boas Postagens sobre Aprendizagens

Contexto: Nos primeiros dois semestres os alunos foram produzindo suas narrativas com base nas orientações de professores e tutores, fossem a partir de explicações gerais ou de comentários em suas postagens. No terceiro semestre foram formados grupos de trabalho para definirem critérios de qualidade e orientar a construção de boas postagens.

Dinâmica: Cada grupo fez uma lista de critérios e posteriormente os grupos apresentaram para a classe inteira, dando surgimento a uma comparação e mesclagem das listas, produzindo uma lista consolidada para toda a turma. Esta lista passou a ser usada como apoio pelos próprios alunos para analisarem as suas postagens e para apoiar a critica às postagens dos colegas, espontaneamente ou quando convidados.

Esses critérios foram apresentados por cada grupo e a seguir foram consolidados para nortear a produção das postagens subsequentes e apoiar as críticas e contribuições dos pares quando em visita ao portfólio de um colega.

4.1.4 Arquitetura Pedagógica 4: Trajetórias de Aprendizagem mediante análise do Portfólio

Contexto: Dentro da ideia de criar um ecossistema cognitivo, utilizamos como uma das suas arquiteturas o Portfólio de Aprendizagens, construído por cada aluno, no decorrer de um curso de formação de professores que atuam na Educação Básica. O Portfólio visa apoiar os processos de aprendizagem e servir de apoio aos processos avaliativos ao final de cada semestre.

O portfólio constitui-se pelo registro de postagens relacionadas a aprendizagens e vivências no curso e nas salas de aula, vinculadas a propostas do curso, principalmente aquelas que estabeleçam fortes relações com o aporte das temáticas do curso. As postagens são comentadas pelos tutores, por docentes formadores e pelos colegas, buscando a criação de uma rede que favoreça debates e conflitos cognitivos capazes de dar origens a reconstruções de ideias e ações pedagógicas. (CHARCZUK et. al. 2017)

Em diversas etapas do curso, os participantes são convidados a analisar a qualidade das postagens realizadas no portfólio, como estratégia para dar a eles a oportunidade de avaliar e tomar consciência dos seus avanços e também das dificuldades relativas ao desenvolvimento da sua capacidade reflexiva.

Dinâmica e mediação: No quinto semestre do curso (o curso é composto por nove semestres), os alunos foram desafiados a analisar as postagens dos primeiros 4 semestres, propiciando um momento de meta-reflexão sobre a suas trajetórias de formação desde o ingresso no curso.

A proposta de trabalho consistiu, inicialmente, em identificar cada postagem com uma das categorias elaboradas com base em Alarcão (1996) apresentadas no Quadro I.

Para cada dois semestres, foi produzido um relatório no formato digital. Após a leitura e debates sobre o conceito de professor reflexivo o grupo foi organizado em duplas. Dessa forma, cada aluno realizou a análises das suas postagens e a análise da postagem do seu colega, dentro da abordagem de revisão por pares. As análises foram realizadas em etapas, resultando, cada uma delas em: (1) análise das próprias postagens e análise das postagens do seu par; (2) discussão das divergências e produção de documento de consolidação, no qual a dupla apresenta uma análise conjunta consensual. Considerando que a arquitetura busca instaurar "ações de reflexão sobre a prática e articulações com a pesquisa" ou ações reconstrutivas, a arquitetura propôs a postagem de um único documento consolidado para cada aluno-professor.

Ao final do semestre foi proposta aos alunos-professores uma discussão e um espaço para que eles pudessem registrar as potencialidades e as fragilidades observadas, bem como o planejamento de ações visando o desenvolvimento da capacidade reflexiva e melhoria da arquitetura proposta.

Quadro I – Categorias de Postagens - Fonte: Charczuk et al. 2017

Tipos de postagens	Descritores
Descritivas	O aluno-professor descreve o que fez e o que aconteceu em sua sala de aula ou em alguma situação de ensino e/ou de aprendizagem. Nestas postagens os fatos são narrados de forma descritiva de acordo com situações pessoais ou profissionais.
Questionadoras	As postagens ultrapassam a descrição de situações que ocorrem na sala de aula e na escola com a introdução de questionamentos e posicionamento pessoal sobre as práticas docentes e as relações que se estabelecem na escola (sua e de outros professores). Outros pontos de vista são abordados e evidenciam relação com novas aprendizagens, ainda que os possíveis conflitos não sejam discutidos.
Reflexivas/ Reconstrutivas	A postagem do aluno-professor ultrapassa a descrição e o questionamento, mediante a busca de uma melhor compreensão da sua prática docente, seja na sala de aula, seja em outros espaços educativos. O aluno-professor apresenta e discute suas ações, mostrando como as suas descobertas, as suas compreensões e o aprofundamento das relações entre a teoria e a prática levaram a mudanças nas sua prática.

4.2 Resultados parciais da aplicação da AP 4

Considerando que a formação do professor reflexivo não acontece de forma espontânea, um projeto que vise essa formação deverá criar um ambiente rico em estratégias que articulem a prática pedagógica e a pesquisa/reflexão.

Os resultados parciais mostram que a arquitetura aponta características que favoreceram atitudes de investigação por parte dos professores-alunos. Como exemplo desses resultados realizamos uma análise dos portfólios de 25% dos alunos de uma das turmas que vivenciaram a arquitetura, escolhidos de forma aleatória, totalizando 15 alunos-professores. Essa amostra foi composta por alunos-professores adultos (entre 30 a 45 anos) que atuam em escolas situadas no Estado do Rio Grande do Sul (BR). Para essa análise foram consideradas os documentos produzidos por cada aluno-professor, incluindo a análise do próprio portfólio, a análise do portfólio de um colega nos quatro semestres do curso e ainda as reflexões registradas sobre a experiência. Como resultado destaca-se:

-Em nenhum caso ocorreu consenso inicial entre a autoanálise e a análise realizada pelo par. Essa situação criou, conforme previsto, confrontos entre os pontos de vista dos alunos-professores que os levou a rediscutir e avaliar os tipos de postagem realizados, além de analisar as características das postagens e sua adequação ao objetivo de formação do professor reflexivo. Esse confronto criou condições favoráveis às trocas e provocou tomadas de consciência, já que cada aluno-professor foi solicitado a justificar ou reconstruir o seu posicionamento em relação as postagens analisadas, como mostra o relato a abaixo:

> *Nessa etapa, após muitas discussões sobre o que significa cada postagem e o entendimento que cada uma de nós teve da postagem do outro, chegamos a conclusão que a (nome do aluno-professor) estava certa nas suas observações, principalmente na parte da minha análise sobre o blog dele, que eu estava esquecendo que eram postagens do primeiro semestre, onde ainda estávamos nos apropriando da escrita construtiva e reflexiva. O debate para consolidar as postagens demorou mais do que o esperado, porque fizemos questão de explicar postagem por postagem, isso tornou muito mais rico nossa análise e pudemos compreender melhor a escrita do colega. Aluno-professor 1*

- Foi possível identificar que nos primeiros semestres (semestre I e II) prevaleceram, em doze (12) dos quinze (15) portfólios analisados, as postagens do tipo descritivas e percepções/emoções relacionadas ao ingresso no curso. Nos semestres seguintes (III e IV) evidencia-se um movimento que resulta em um aumento das postagens reflexivas/reconstrutivas e uma diminuição das postagens descritivas. Isso ocorre em onze (11) dos quinze (15) portfólios. Esse movimento foi relato nos documentos de análise, conforme exemplo a seguir:

> *Analisando as postagens da colega (nome da colega) e das minhas próprias postagens, em ambas prevaleceu as postagens reflexivas/reconstrutivas. Percebe-se que a partir do eixo III e consolidado no eixo IV, as postagens reflexivas aconteceram em maior quantidade nestes dois últimos eixos, nos dois blogs analisados, sendo que no último eixo foi ainda maior. Isso se deve ao fato, na minha opinião, de que com a prática da escrita reflexiva houve um amadurecimento das ideias e*

construções pessoas, na medida que o ato de escrever passou a ter mais significado e aprofundamento, principalmente devido à prática da escrita. Professor-aluno 2

Essa primeira análise da experiência de uso da arquitetura mostrou que ela ofereceu um "arcabouço estruturante" adequado para amparar o resgate das trajetórias de aprendizagem dos alunos-professores, possibilitando uma análise do desenvolvimento da capacidade reflexiva desses sujeitos. Essa análise mostra algumas regularidades que evidenciam, tanto a importância da realização continuada do portfólio, quanto da sua análise periódica para na formação do professor reflexivo.

5 Considerações Finais

A formação de profissionais reflexivos, em qualquer campo do saber, requer que além da ação, a reflexão também seja exercitada ao longo da formação. Neste trabalho apresentamos uma arquitetura pedagógica na qual professores em formação registram e refletem sobre suas aprendizagens. Como pode ser observado, a AP acima apresentada, não está subordinada a um conteúdo específico, trata-se de uma dinâmica com potencial de uso para apoiar o desenvolvimento de profissionais reflexivos, independentes de sua área de atuação. O relato escolhido neste artigo tomou o contexto de um curso de graduação que forma professores devido a disponibilidade de registros de um número maior de sujeitos. Entretanto, arquitetura semelhante tem sido usada no contexto de um curso de mestrado em informática para dar suporte a diferentes disciplinas tais como: Inteligência Artificial Aplicada à Educação, Ambientes Inteligentes para Aprendizagem, Jogos Digitais e Aprendizagem e Ambientes e Ferramentas para Dinâmica Colaborativas.

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Engineering and Active Learning: five years of literature' review for engineering through the meta-analytical approach

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Abstract

Over the last decades, the world scientific production has exponentially evolved, which caused the high number of publications to become a problem for the literature selection and qualified analysis for studies in order to propose solutions to the old and new difficulties. Nowadays, higher education is facing the challenge of students' "physical presence" in the classroom, but not paying attention or not following along in the class. The active learning arises allowing the student to take a more active position, in which he deal with problems, develops projects and, creates opportunities for the knowledge construction. Many researches are conducted on this subject, however there is a necessity for studies that consolidate knowledge in an integrative model which describes the changes of the state of the art. This study objective is to present the contributions and evolution on Active Learning for education in the Engineering field in the last 5 years. To achieve the objective, a meta-analytic approach was adopted, which includes the main laws of bibliometrics, the Bradford periodic dispersion law, the Lotka authors productivity law, and the Zipf word frequency law, as well as the derived approaches from these authors. The research was performed in the Web of Science database, totaling 635 articles as result. Considering the evolution of the theme during the period of 2012-2017, Prince reached his own nucleus of approach, while the major works are concentrated around the studies of Borrego and Brown. The results contribute to the presentation of a conceptual map integrating the main researches of the area, identifying the most relevant authors, studies and approaches on Active Learning for Engineering courses in the last 5 years (2012-2017) and in the extension of the revision method of literature.

Keywords: Active learning, Engineering, Meta-analytical approach, Web of Science.

Engenharia e Aprendizagem ativa: cinco anos de revisão da literatura para as engenharias por meio do enfoque meta-analítico

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Resumo

Nas últimas décadas a produção científica mundial evoluiu de forma exponencial, isso fez com que o elevado número de publicações se transformasse num problema para a seleção e análise qualificada da literatura para estudos afim de propor soluções para as dificuldades antigas e novas. O ensino superior enfrenta atualmente o desafio do aluno estar presente em sala de aula, mas fazendo outra coisa diferente do que acompanhar a aula. A aprendizagem ativa surge permitindo que o aluno assuma uma postura mais ativa, na qual ele resolve problemas, desenvolve projetos e, com isto, cria oportunidades para a construção de conhecimento. Muitas pesquisas são realizadas a respeito desse tema, porém tem-se a necessidade de estudos que consolidem o conhecimento em um modelo integrador que descreva as mudanças do estado da arte. O objetivo deste estudo é apresentar as contribuições e evolução sobre Aprendizagem Ativa para formação na área de Engenharia dos últimos 5 anos. Para alcançar o objetivo foi realizada a abordagem enfoque meta-analítico que compreende as principais leis da bibliometria, a lei de dispersão de periódicos de Bradford, a lei de produtividade de autores de Lotka, e a lei de frequência de palavras de Zipf, assim como as abordagens derivadas destes autores. A pesquisa foi realizada na base de dados *Web of Science*, com o resultado de 635 artigos. Pode-se perceber que na evolução do tema no período 2012-2017, Prince alcançou seu próprio núcleo de abordagem, enquanto as maiores concentrações dos trabalhos estão ao redor dos estudos de Borrego e Brown. Os resultados contribuem na apresentação de um mapa conceitual integrando as principais pesquisas da área, identificando os autores, estudos e abordagens mais relevantes sobre Aprendizagem Ativa para os cursos de Engenharia nos últimos 5 anos (2012-2017) e na ampliação de um método de revisão da literatura.

Palavras-chave: Aprendizagem ativa, Engenharia, Enfoque meta-analítico, *Web of Science*.

1 Introdução

Um dos grandes desafios encontrados no ensino superior, em especial na educação em engenharia, é modificar a inércia do tradicionalismo pedagógico, estruturado em palestras, tutoriais, técnicas laboratoriais tradicionais e exames finais, geralmente, como a principal avaliação do aluno, levando-o a adquirir um conhecimento superficial de um assunto que poderia ter sido abordado de forma a instigar sua capacidade de resolver problemas através das práticas em engenharia, aprofundando seu conhecimento (Marton, Hounsell & Entwistle, 1984).

Importantes filósofos como Aristóteles (384-322 a.C.), Confuncius (500 a.C.) e Sócrates (400 a.C.), acreditavam que a melhor forma de estimular a aprendizagem é quando os alunos se tornam ativos na construção do seus conhecimentos e não meros receptores de informações. Os alunos devem ser motivados a pensar, questionar e buscar soluções práticas para situações do cotidiano da sua formação. Com base nessa premissa filosófica, por volta de 1970 foi introduzido em algumas faculdades de medicina e engenharia a aprendizagem baseadas em projeto, em inglês *Project Based Learning* – PBL (Christie & Graaff, 2017).

O PBL é uma metodologia voltada ao aprendizado, que proporciona ao aluno a aquisição de conhecimento crítico, proficiência em solução de problemas, estratégias de aprendizagem e habilidades de participação. Uma vez que a mesma exige à pró-atividade do aluno, para que o mesmo procure o conhecimento nos diversos meios de difusão disponíveis e encontre a solução para problemas reais a partir do trabalho em equipe, da discussão e da análise crítica (Campos, Dirani, & Manrique, 2011).

Segundo Lima, Andersson, & Saalman (2017), um dos principais desafios atualmente da aprendizagem ativa na educação em engenharia é voltar a origem da aprendizagem ativa, buscar exemplos práticos e usar como principais métodos de ensino para atender os desenvolvimentos atuais do ensino superior, juntamente com o seu avanço tecnológico.

Assim, este artigo busca identificar os principais e mais atuais estudos realizados, através de uma investigação das propostas mais relevantes, com relação ao tema Aprendizagem ativa com foco em engenharia. Avaliou-se a evolução dos estudos sobre este tema nos últimos 5 anos, utilizando o enfoque meta-analítico, que se trata de uma abordagem derivada da meta análise, porém com um objetivo distinto de mapear a literatura, propondo marcos conceituais (Mariano et. al., 2011). A seguir, apresenta-se na seção 2 a metodologia da pesquisa, e na seção 3 descrevem-se os resultados obtidos através de enfoque meta-analítico. Na seção 4 apresenta-se a conclusão da pesquisa e sugerem-se futuros trabalhos e por fim na seção 5 as referências deste estudo.

2 Metodologia da pesquisa

A metodologia adotada foi a pesquisa bibliográfica de caráter exploratório por meio do enfoque meta-analítico. O enfoque meta-analítico utiliza o critério de impacto de revistas e artigos para escolha do material a ser utilizado. Tem como objetivo combinar bases de dados conceituadas, para dessa forma apresentar uma base de material confiável. O enfoque meta-analítico possibilita obter os melhores autores, artigos e revistas, e também realizar uma análise das técnicas estatísticas, das técnicas amostrais, das linhas mais pesquisadas e das abordagens utilizadas (Mariano et. al., 2011). Nesse trabalho, adotou-se enfoque meta-analítico (Mariano et. al., 2011), adaptado em 5 passos: Análise e apresentação das revistas da disciplina; Seleção de revistas relevantes da disciplina; Coleta de dados para alimentação da base de dados; Análise dos autores, artigos e abordagens e Análise das Palavras Chaves. Foi utilizado o software VOSviewer versão 1.6.5 para elaboração de mapas de calor. Esses mapas usam cores mais quentes e fontes em negrito para enfatizar autores/conceitos que são usados com frequência, enquanto as palavras que são usadas apenas esporadicamente são mostradas em cores mais frias e fontes menores (Zupic & Čater, 2015).

3 Resultados

A seguir são apresentados os resultados obtidos utilizando as 6 etapas de implementação da pesquisa bibliográfica de caráter exploratório por meio do enfoque meta-analítico com o tema Aprendizagem Ativa e Engenharia.

3.1 Análise e apresentação das revistas da disciplina

Essa análise foi realizada por meio da base de dados da: ISI *Web of Science* no período de 08 a 09 de outubro de 2017. Segundo (García & Ramirez, 2004) a *ISI Web of Science* é conhecida internacionalmente como uma das melhores e mais completas. Foram pesquisadas as revistas relacionadas aos principais congressos relacionados ao domínio relacionado ao tema. A base do *ISI Journal Citation Report Edition* apresenta 236 revistas, considerando a área do conhecimento Educação e Pesquisa educacional.

Atualmente a ciência estabeleceu critérios para valorar os meios de veiculação dos trabalhos científicos, chamado de Fator de Impacto (FI). Embora existam críticas sobre o fator de impacto quanto indicador de qualidade, atualmente é o mais aceito e utilizado. (Mariano & Santos, 2017). Conhecer as revistas mais importantes da área é um critério de seleção consolidado na comunidade acadêmica. Segundo a *ISI (Institute for Scientific Information)*, responsável por elaborar os fatores de impacto para as diferentes revistas científicas, os periódicos considerados mais relevantes para Educação são *Educational Psychologis*, com fator de impacto de 6.257, *Review of Educational Research*, com 5.263, *Internet and Higher Education*, com 4.238, *Learning and Instruction*, com 3.983 e *Educational Research Review*, com 3.839.

Identificadas as revistas com maior fator de impacto, foi realizada a busca "*Active learning*" e "*engineering*" no espaço temporal de cinco anos (2012-2017). O resultado encontrado foram 635 artigos na *Web of Science* sobre o tema. Porém, nem sempre as revistas com maior fator de impacto são as que mais publicam. As principais revistas que publicaram sobre o tema com seus respectivos fatores de impacto são *International Journal of Engineering Education*: 42 publicações e 95 citações, FI= 0.609; *IEEE Transactions on Education*: 13 publicações e 138 citações, FI=1.727; *Journal of professional Issues in Engineering Education and Practice*: 11 publicações e 18 citações, FI=0.921; *Computer Applications in Engineering Education*: 8 publicações e 32 citações, FI=0.694; *Journal of Engineering Education*: 7 publicações e 36 citações, FI=3.047.

Assim, pode-se perceber que as revistas que mais publicaram sobre o tema não são aquelas de maior fator de impacto para a área de Educação, sugerindo que apesar do tema ser relevante, ainda não alcançou os periódicos mais relevantes da área. Entretanto, esta questão pode estar relacionada com o fato dessas revistas não publicarem tanto sobre educação em engenharia.

A Figura 1 apresenta o quantitativo de publicações, imagem do lado esquerdo, e apresenta a evolução do quantitativo de citações, imagem do lado direito, desde 2012, considerando a base da *Web of Science*. As citações e os artigos desta base têm crescido substancialmente. Isso demonstra o interesse dos pesquisadores nesse assunto. Segundo (Mariano & Santos, 2017), o crescimento de citações e quantidade de artigos publicados revela a importância científica do tema, conforme a Lei de Obsolescência da Literatura e Teoria Epidêmica de Goffman, responsáveis por mensurar o declínio ou progressão de determinada área de conhecimento baseando-se nas publicações e citações de sobre um tema.

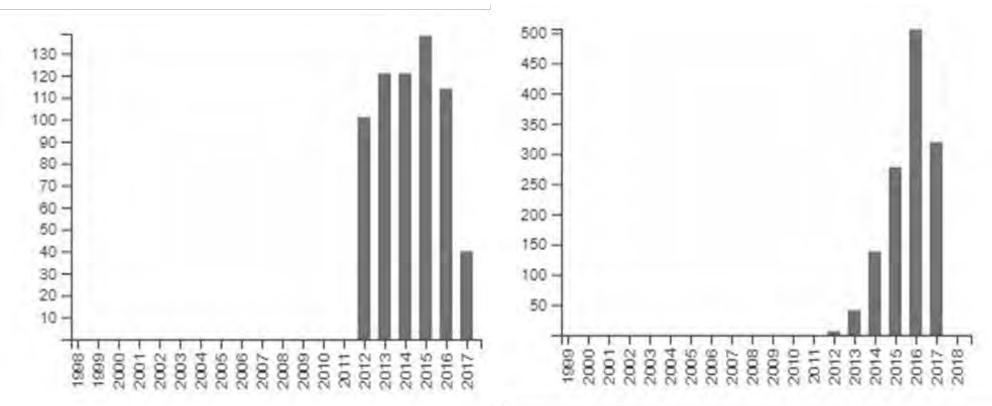

Figura 13. Evolução do quantitativo de publicações e evolução do quantitativo de citações desde 2012

Fonte. Base *Web of Science*

3.2 Análise dos autores, artigos e abordagens

Para análise dos autores e dos artigos, ou seja, uma visualização da estrutura conceitual da área, optou-se pelo uso de gráficos chamados mapas de calor. Esses mapas usam cores mais quentes e fontes em negrito para enfatizar autores/conceitos que são usados com frequência, enquanto as palavras que são usadas apenas esporadicamente são mostradas em cores mais frias e fontes menores (Zupic & Čater, 2015). Foram usadas duas análises bibliométricas de *Co-citation* (Figura 2) e o *Bibliographic Coupling* (Figura 3). O método de *Co-citation* conecta diferentes autores, documentos e revistas baseado nas aparições em conjunto na lista de referência obtida através das bases de dados. O método de *Bibliographic Coupling* projeta os fronts de pesquisa desde a perspectiva de que trabalhos que estão citando juntos trabalhos importantes devem tratar do tema desde uma perspectiva similar.

Nas Figura 2 apresenta um mapa de calor de *Co-citation* no período de 2012-2017. Quanto mais próximos os autores, maior a similaridade dos trabalhos e quanto maior for seu nome, mais citado ele foi. Analisando os trabalhos que se destacam entre 2012-2017, levando-se em consideração os núcleos de calor em um tom avermelhado e amarelo, pode-se perceber que se destaca (Prince, 2004) que analisa a evidência da eficácia da aprendizagem ativa, define as formas comuns de aprendizagem ativa mais relevantes para professores de engenharia e examina criticamente o elemento central de cada método. Verifica-se que há um apoio amplo e desigual para os elementos centrais da aprendizagem ativa, colaborativa, cooperativa e baseada em problemas. Já (Felder & Silverman, 1988), discutem quais aspectos do estilo de aprendizagem são particularmente significativos na educação de engenharia, quais estilos de aprendizagem são preferidos pela maioria dos alunos e que são favorecidos pelos estilos de ensino da maioria dos professores e o que pode ser feito para chegar a estudantes cujos estilos de aprendizagem não são abordados por métodos padrão de educação de engenharia. Reforça que a ideia não é usar todas as técnicas em todas as classes, mas preferir escolher várias que parecem viáveis e experimentá-las. O trabalho de (Hake, 1988), apresenta um estudo sobre o uso de Interação Interativa (IE) em cursos com a disciplina física introdutória, o mesmo chega à conclusão que os resultados sugerem fortemente que o uso de métodos de IE pode aumentar a eficácia do curso bem além da obtida na prática tradicional. Por sua vez (Prince & Felder, 2005), fazem uma análise de vários métodos de ensino indutivo mais utilizados, incluindo aprendizado de informações, aprendizado baseado em problemas, aprendizado baseado em projetos, ensino baseado em casos, aprendizagem de descoberta e ensino *just-in-time*. Eles chegam à conclusão que os métodos indutivos são, em geral, mais eficazes do que os métodos tradicionais dedutivos para alcançar uma ampla gama de resultados de aprendizagem.

Pode-se perceber extensos estudos abordam a importância de uma Aprendizagem ativa, está se tornou uma técnica respeitada e em crescimento, com um grande número de sucessos e que as críticas não estão associadas a valia do método e sim a priorização de melhora cada vez mais.

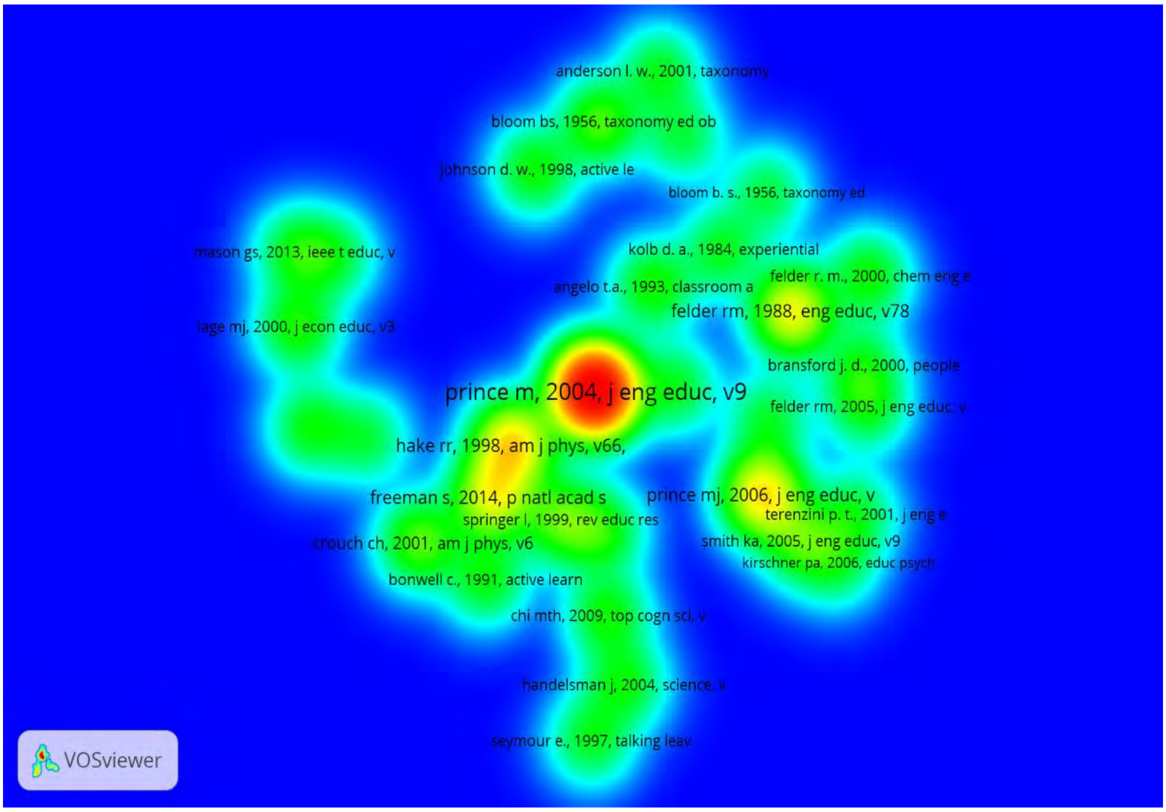

Figura 2. Mapa de densidade de *Co-Citation* entre 2012-2017

Fonte. *Web of Science*, extraído do software VOSviewer

Já na Figura 3, foi realizada a análise de *Bibliographic Coupling*, com a finalidade de encontrar aqueles trabalhos que são fronts de pesquisa neste momento, linhas sólidas sobre Aprendizagem ativa. Procedeu-se a análise dos trabalhos que se destacam entre 2012-2017, levando-se em consideração os núcleos de calor em um tom avermelhado. Inicialmente pode-se perceber o trabalho de (Borrego, Prince, Nellis, Shekhar, Waters & Finelli, 2014), que evidencia que as estratégias de instrução baseadas na pesquisa (RBIS), como a aprendizagem ativa, são eficazes no aumento da aprendizagem dos alunos, mas a taxa de adoção de tais estratégias tem sido lenta. Já o estudo de (Chen, Brown, Crawford, Jensen, Rencis, Liu, Watson, Jackson, Hackett, Schimpf, Orabi, Akasheh, Wood, Dunlap & Sargent, 2013), que em resposta à necessidade de introduzir *undergrades* no método dos elementos finitos, bem como a necessidade de currículos de engenharia para incluir uma aprendizagem mais ativa, desenvolvem, implementam e avaliam um conjunto de Módulos de Aprendizagem Ativa (ALMs).

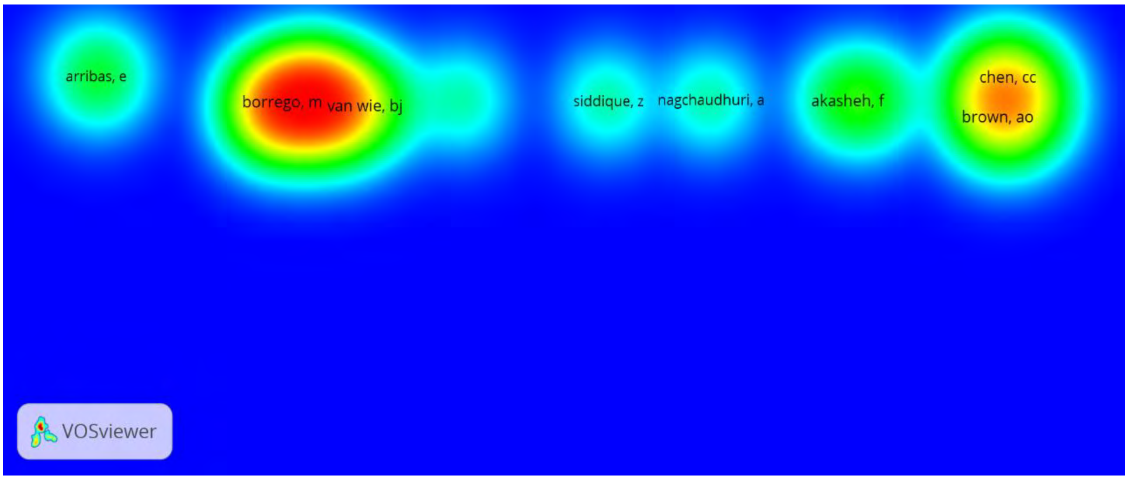

Figura 3. Mapa de densidade de *Bibliographic Coupling*

Fonte. *Web of Science*, extraído do software VOSviewer

3.3 Análise das Palavras Chaves

Finalmente foi realizada uma análise da frequência das palavras-chave dos artigos entre 2012-2017 da base *Web of Science* com o intuito de ratificar as principais linhas de estudo dos últimos anos (Figura 4).

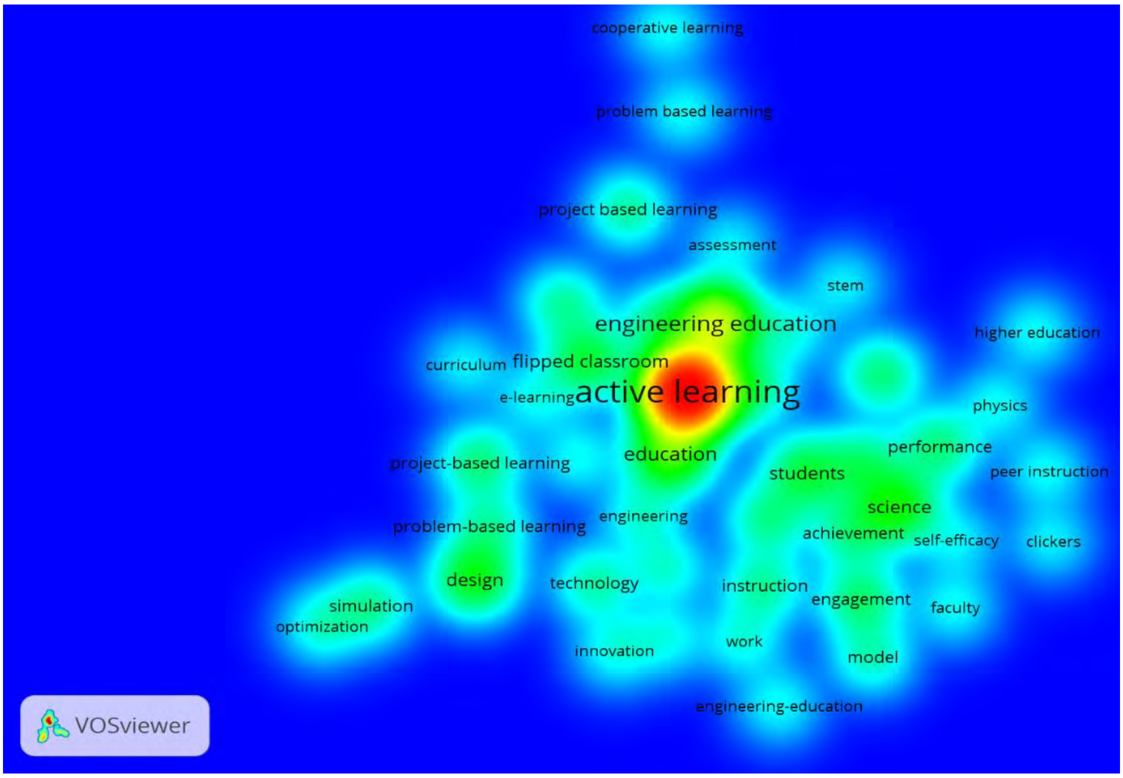

Figura 4. Mapa de densidade das palavras-chave

Fonte. *Web of Science*, extraído do software VOSviewer

Como resultado destacaram-se as palavras-chave *active learning, curriculum, design, performance, Project-based learning, problem-based learning, e-learning, tecnology, innovation, simulation e optimization*. Ou seja, pesquisas que analisam o uso do e-Learning, como uma tecnológica, para apoiar a aprendizagem dos alunos dentro de um ambiente simulado. Outra vertente seria estudos voltados ao aprimoramento do desenho curricular de cursos com o uso do *Project based learning* (PBL). Outra linha de pesquisa possível seria uma análise de performance/sucesso através da avaliação de alunos sobre uma implementação da PBL, por exemplo em cursos de graduação ou pós-graduação em engenharia.

Assim, pode-se perceber que o tema Aprendizagem ativa vem sendo um método bastante estudado e vem sendo apresentado na literatura científica com resultados reais em diferentes contextos e com ganhos no desenvolvimento de habilidades e competências comportamentais, como relacionamento interpessoal, trabalho em equipe, comunicação, gestão de problemas, além de ganhos para o futuro profissional e aproximação ao mercado de trabalho.

4 Conclusão

O objetivo geral foi avaliar a evolução dos estudos sobre Aprendizagem ativa nas engenharias nos últimos 5 anos, utilizando o enfoque meta-analítico. A metodologia da pesquisa foi a pesquisa bibliográfica de caráter exploratório, realizando uma adaptação do enfoque meta-analítico.

Os resultados identificaram que existe uma forte linha de abordagem que analisa a evidência da eficácia da aprendizagem ativa, define as formas comuns de aprendizagem ativa mais relevantes para professores de engenharia e examina criticamente o elemento central de cada método. Pode-se perceber extensos estudos que abordam a importância de uma Aprendizagem ativa, evidenciando ser uma técnica respeitada e em crescimento, com um grande número de sucessos e que as críticas não estão associadas a valia do método e sim a priorização de melhora cada vez mais.

Assim, pode-se perceber que aplicando o enfoque meta-analítico, é possível mapear a literatura, identificando os estudos mais relevantes de uma determinada área. Como sugestão de trabalhos futuros, a aplicação do enfoque poderá ser expandida para outras bases.

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The construction of the project evaluation concept in a team of teachers

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Abstract

The school is the setting where students seek knowledge. In turn, it is extremely important to measure the knowledge obtained, without that, there is no parameter to know the effectiveness of the work performed. It is necessary to overcome the traditional evaluation system, which is composed of tests, work, seminars, which but often is not aligned with all the dimensions of the desired learning. The inadequacy of the evaluation process is due to the fact that learning goes beyond the specific technical knowledge of the disciplines, which is not always well understood by teachers, so that the transversal skills students need to develop in school are not adequately assessed. The competences necessary to the modern professional require the restructuring of the evaluation process, aligned with strategies and new learning objectives. In particular, for transverse skills, it is necessary to identify indicators to measure student's learning at the school process. In order to promote the improvement on the process and evaluation instruments, an engineering school have been organizing a work with a group of teachers, to analyze and reflect on objective and ways of evaluating the students. They are workshops in which teachers are too, encouraged to create rubrics for these assessments. The aim of this work is to identify the perception of the teachers about the evaluation process in projects, as well as to identify what instruments that they propose to evaluate the transversal skills in the engineering student's qualification. To the school, there is the interest to develop rubrics that become the standard of evaluation of projects developed by students. The question is how to promote an assessment to measure and gives feedback to the student about the development of transversal competences?

Keywords: Learning Evaluation, Rubric, Soft Skills, PBL, Teacher Training

A construção do conceito de avaliação de projetos em uma equipe de professores

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Resumo

A escola é o cenário onde os alunos procuram conhecimento. Por sua vez, é extremamente importante medir o conhecimento obtido, sem isso, não há parâmetros para conhecer a eficácia do trabalho realizado. É necessário superar o sistema de avaliação tradicional, que é composto de testes, trabalhos, seminários, que, muitas vezes, não estão alinhados com todas as dimensões da aprendizagem desejada. A inadequação do processo de avaliação deve-se ao fato de que a aprendizagem ultrapassa o conhecimento técnico específico das disciplinas, o que nem sempre é bem entendido pelos professores, de modo que as habilidades transversais que os alunos precisam desenvolver na escola não são adequadamente avaliadas. As competências necessárias ao profissional moderno exigem a reestruturação do processo de avaliação, alinhado com estratégias e novos objetivos de aprendizagem. Em particular, para as habilidades transversais, é necessário identificar indicadores para medir a aprendizagem do aluno no processo escolar. A fim de promover a melhoria dos processos e instrumentos de avaliação, uma escola de engenharia tem organizado um trabalho com um grupo de professores, para analisar e refletir sobre objetivos e formas de avaliar os alunos. São oficinas em que professores também são incentivados a criar rubricas para essas avaliações. O objetivo deste trabalho é identificar a percepção dos professores sobre o processo de avaliação em projetos, bem como identificar os instrumentos que eles propõem para avaliar as habilidades transversais na qualificação do aluno de engenharia. Para a escola, há o interesse de desenvolver rubricas que se tornem padrão de avaliação de projetos desenvolvidos pelos alunos. A questão é como promover uma avaliação para medir e dar feedback ao aluno sobre o desenvolvimento de competências transversais?

Palavras Chaves: Avaliação da Aprendizagem, Rubrica, Competências Transversais, PBL, Formação de Professores.

1 Introdução

A escola é o cenário no qual se busca o conhecimento e, para medir o que e quanto se alcançou de conhecimento, tanto professores como estudantes envolvidos no processo de ensino-aprendizagem de engenharia, reconhecem que os alunos têm que passar por um sistema de avaliação que tradicionalmente é composto por provas, trabalhos, seminários, etc. Esse sistema muitas vezes não é adequado à verificação da aprendizagem desejada e valorizada nos dias atuais, e que vai muito além da aprendizagem do conhecimento técnico específico das disciplinas. As mudanças nos currículos, com a introdução de estratégias que vão para além do ensino tradicional traz a percepção que a avaliação no ensino superior se torna cada vez mais importante, tanto como instrumento de medição do conhecimento adquirido, mas principalmente como ferramenta para a melhoria da aprendizagem.

A pergunta que se coloca é: Considerando que os alunos que chegam à universidade trazem novas e diferenciadas experiências em sua história de vida, deve-se continuar a atuar na sala de aula como se atuava no século passado? Mais precisamente, deve-se avaliar tal como se fazia num sistema de ensino tradicional que prevalecia como prática no ensino superior?

O presente trabalho tem como objetivo identificar a percepção dos professores de uma escola de engenharia sobre o processo de avaliação e mais precisamente a avaliação pela participação em projetos, bem como identificar instrumentos que possam ser utilizados para avaliar as competências transversais desejáveis na formação do estudante de engenharia. A partir desse estudo, deseja-se desenvolver rubricas que se tornem padrão de avaliação dos projetos desenvolvidos pelos estudantes.

2 Revisão Bibliográfica

A sociedade está mudando rapidamente e essas mudanças demandam a formação de engenheiros com muito mais qualificações do que com apenas um alto nível de especialização técnica ou científica. Essas demandas exigem reflexões sobre os objetivos e as funções da avaliação no ensino de engenharia (Moreira, Gravonski, & Fraile, 2012).

A maioria das estratégias utilizadas no ensino de engenharia ainda está apoiada em um modelo de educação tradicional, no qual o professor é o detentor do saber e o aluno apenas um receptor passivo (Mizukami, 1986). Entretanto, esse modelo tem se mostrado ineficiente diante das atuais necessidades dos discentes e das exigências da sociedade, o que já há algum tempo é indicado nas Diretrizes Curriculares dos cursos de Engenharia (MEC, 2002).

Novas estratégias de ensino tais como aprendizagem baseada em problemas, ensino por projetos, necessitam de novas ferramentas de avaliação, como por exemplo, auto avaliação, avaliação por pares, portfólios, etc.

Apesar da importância dada na literatura para o tema, ainda encontramos muitas IES, com um modelo acadêmico tradicional sem conexão entre teoria e prática e com sistema de avaliação que se baseia na classificação e na promoção dos alunos e não na aprendizagem. Isso ocorre porque o professor de engenharia, muitas vezes engenheiro por formação, por não ter especialização na área pedagógica não consegue acompanhar, de maneira satisfatória, essas mudanças. Esse fato gera grande defasagem entre os objetivos propostos e os realmente alcançados em um curso superior. Pode-se atribuir a isso o fato do professor não ter conhecimento específico para o desenvolvimento, ou mesmo uso, de novas tecnologias de trabalho e avaliação.

Repensar a avaliação é um desafio complexo que exige a análise de vários fatores, como os tipos de instrumentos utilizados, o papel desses instrumentos e as escalas para a medição do conhecimento atingido pelos estudantes.

Avaliação é um substantivo feminino que significa ato de avaliar. Pode ser sinônimo de estimativa ou apreciação. No âmbito da pedagogia, a avaliação escolar é um processo sistematizado de registro e apreciação dos resultados obtidos em relação a metas educativas estabelecidas previamente. A avaliação da aprendizagem escolar se faz presente na vida de todos que estão comprometidos com atos e práticas educativas.

Durante muito tempo, a avaliação foi usada como instrumento para classificar e rotular os alunos entre os bons, os que dão trabalho e os que não têm jeito. A prova bimestral, por exemplo, servia como uma ameaça à turma. Segundo Luckesi (2000) "A avaliação da aprendizagem não é e não pode continuar sendo a tirana da prática educativa, que ameaça e submete a todos. Chega de confundir avaliação da aprendizagem com exames".

Nos dias de hoje, a avaliação da aprendizagem não é algo meramente técnico. Envolve autoestima, respeito à vivência e cultura própria do indivíduo, filosofia de vida, sentimentos e posicionamento político. O educador que faz uso de instrumentos de avaliação diversos para, ao longo de um período, acompanhar o ensino-aprendizagem, é diferente daquele que se restringe a dar uma prova ao final do período.

Ainda segundo Luckesi (2000),

> A avaliação da aprendizagem, por ser avaliação, é amorosa, inclusiva, dinâmica e construtiva, diversa dos exames, que não são amorosos, são excludentes, não são construtivos, mas classificatórios. A avaliação inclui, traz para dentro; os exames selecionam, excluem, marginalizam.

Hoje em dia a avaliação é vista como uma importante ferramenta à disposição dos professores para alcançar o principal objetivo da escola: fazer com que os estudantes evoluam. É de extrema importância encontrar caminhos para medir a qualidade do aprendizado e oferecer alternativas para uma evolução mais segura. Sabemos que a avaliação tem papel de grande importância no processo ensino aprendizagem. Talvez seja o principal instrumento diagnóstico para o conhecimento da realidade cognitiva, intelectual e formativa de um grupo.

Avaliar consiste do ato de mensurar, medir, dimensionar, quantificar ou qualificar algo que se deseja atribuir valor ou grau; é o ato de diagnosticar. Para esse fim são aplicados métodos, instrumentos e ferramentas que devam ser pensados de forma a se adequar ao objeto, fato ou fenômeno a ser avaliado (Oliveira, 2016).

Os métodos avaliativos devem estar relacionados aos instrumentos, recursos pedagógicos e métodos de ensino utilizados. Segundo Oliveira (2016),

> Os resultados das avaliações devem descrever além das dificuldades e deficiências da aprendizagem dos alunos, as dificuldades e deficiências dos docentes, fato que torna a avaliação não apenas um mecanismo classificatório, mas um instrumento diagnóstico do conjunto do processo de ensino aprendizagem, porém é recorrente dentre os educadores um discurso diferente da prática, no qual o processo avaliativo ainda é ditado pelo chamado ensino tradicional não representando os conceitos modernos já tão difundidos.

Notadamente a pedagogia adotada nos cursos de engenharia está inadequada à aprendizagem dos educandos. A ação didática pedagógica dos professores deve conduzir os acadêmicos à consciência da responsabilidade por sua aprendizagem.

Segundo Menestrina (2009), para que isto ocorra:
- O acadêmico precisa ser o componente mais importante do processo;
- O professor deixa de ser o transmissor de conhecimentos;
- A formação do engenheiro passa a ser encarada de forma holística;
- A avaliação deve ser um processo de retroalimentação permanente;
- O trabalho em equipe deve ser exercitado.

Espera-se que o professor tenha um papel relevante como mediador no processo de ensino-aprendizagem, priorizando a participação do aluno e gerenciando suas expectativas e habilidades. O professor, conhecedor do conjunto de fatores que permeiam o processo de ensino-aprendizagem, não pode preocupar-se somente em mostrar o conhecimento que possui ou apresentar o conteúdo estudado. Ele deve procurar problematizar uma situação, possibilitando ao aluno ser mais investigativo. Dessa forma, o aluno se sente estimulado a sair do contexto de memorização de conteúdos e passa a contribuir com o próprio aprendizado (Silva, *et al*., 2016).

Em seu trabalho Neuenfeld (2010) afirma que:

> [...] vários estudos começam a ser realizados, abrindo espaços dentro das instituições para práticas que valorizam o aluno e exige dos professores a tomada de consciência de suas práticas enquanto educadores. Essas atitudes tornam necessárias as reflexões sobre o processo de ensinar e aprender, proporcionando a toda comunidade escolar e a sociedade em geral, uma escola mais crítica e adequada aos seus indivíduos.

Atualmente uma das metodologias ativas de ensino mais utilizadas em engenharia, com o objetivo de substituir o processo tradicional de ensino, é o *Problem Based Learning* - PBL, método de aprendizagem baseado em problema. É um método de ensino no qual a aprendizagem se dá a partir da resolução de problemas. No PBL, a participação dos estudantes é bem mais ativa, pois o objetivo principal é o desenvolvimento de soluções para um problema. Já o professor não é mais o centro do processo, tem como principal função gerir os recursos necessários e direcionar a resolução dos problemas propostos.

Na literatura encontramos como vantagens da utilização do PBL:
- Tornar a aprendizagem mais dinâmica e envolvente;
- Fomentar um ambiente de aprendizagem no qual se tem mais atitudes altruístas;
- Estimular a criação de parcerias entre estudantes e docentes;
- Praticar e desenvolver habilidades comunicativas e sociais;
- Aprender a respeitar opiniões diversas e a construir consensos, a partir do trabalho em grupo;
- Desenvolver responsabilidade com relação ao cumprimento de planos e prazos;
- Desenvolver a capacidade de estudo e trabalho autorregulado.

Segundo Araújo *et al* (2016), o método pode ser usado para desenvolver capacidades que serão requeridas dos estudantes quando estiverem formados e atuando profissionalmente.

O trabalho de Lima *et al* (2017) apresenta as competências normalmente requeridas na contratação de engenheiros. Os dados foram obtidos a partir de pesquisas em 1391 anúncios publicados em jornais durante 7 anos. Nesse trabalho, as 10 competências mais exigidas estão indicadas no Quadro 1.

Quadro 1 – As dez competências encontradas por Lima et al (2017)

	Competências transversais	%
1	Língua estrangeira	18,5
2	Tecnologia da informação e comunicação	11,5
3	Trabalho em equipe	8,2
4	Comunicação	7,0
5	Liderança	6,7
6	Planejamento e organização	6,5
7	Iniciativa	6,0
8	Dinamismo	5,0
9	Relacionamento interpessoal	4,8
10	Autonomia e responsabilidade	4,2

Em muitos casos, quando da utilização do PBL em cursos de engenharia, emprega-se um modelo híbrido, no qual o currículo incorpora um componente central em que problemas e projetos são trabalhados por grupos de estudantes apoiados por tutores. Uma vez apresentado o problema, os estudantes deverão buscar conhecimentos para lidar com ele, desenvolvendo, assim, habilidades e atitudes para a solução do caso. Cabe ao professor acompanhar todo o processo, corrigir rumos e verificar se os conhecimentos que estão sendo adquiridos pelos estudantes estão inseridos na disciplina e se contribuirão para a solução final do problema (Araújo, Lopes, Filho, Barros, & Oliveira, 2016).

A utilização do PBL nos cursos de engenharia trouxe à tona um velho problema enfrentado por professores e alunos: a avaliação do processo ensino-aprendizagem. Não faz sentido avaliar um novo processo, com caraterísticas distintas, com as mesmas ferramentas utilizadas no processo tradicional de ensino. Vale salientar que mesmo no processo tradicional de ensino, as técnicas de avaliação estão sendo repensadas.

Segundo Moreira *et al* (2015) um dos caminhos para promover a avaliação de qualidade é a adoção de um sistema avaliativo que envolva os alunos no processo e que tenha como objetivos melhorar o desenvolvimento de competências profissionais, os níveis de aprendizagem e o sucesso acadêmico dos alunos. Atualmente as universidades entendem as competências de forma mais amplas, como por exemplo, a capacidade de aprender a aprender, não apenas durante o tempo na universidade, mas também durante toda a vida profissional. Essas demandas exigem reflexões sobre os objetivos e as funções da avaliação no ensino de engenharia. Assim, a avaliação no ensino superior está se tornando cada vez mais importante como ferramenta para a melhoria da aprendizagem, pois a maneira com que os alunos pensam sobre aprender e estudar, determina a maneira com que abordam as atribuições e tarefas de avaliação.

Para avaliar, primeiro precisamos diagnosticar. Para diagnosticar, precisamos coletar dados relevantes. Para coletar dados, necessitamos instrumentos. Para atingir esse objetivo, três pontos básicos precisam ser levados em consideração:

1. **Dados Relevantes:** os dados coletados não podem ser quaisquer. Deverão ser essenciais para aquilo que se pretende avaliar;
2. **Instrumentos:** um instrumento inadequado ou defeituoso pode distorcer completamente a realidade, pode ser desastroso;
3. **Utilização dos Instrumentos:** qualquer que seja o instrumento – prova, teste, monografia, etc. – deve apresentar qualidade como instrumento na avaliação da aprendizagem escolar. Caso contrário pode qualificar inadequadamente e, consequentemente, praticar injustiças.

Outra estratégia de sucesso nos cursos de engenharia é o *Project Based Learning* - PjBL, que guarda algumas características próprias quando comparado com o *Problem Based Learning*. Ainda que o PBL e o PjBL tenham diversos pontos em comum, o trabalho de Sesoko e Mattasoglio Neto (2014), faz um levantamento comparando essas estratégias e indicando a diferença de percepção sobre a avaliação entre elas.

Para Fernandes, Flores e Lima (2010) a avaliação no PjBL deve ser um processo contínuo, que inclui essencialmente três etapas: delinear, obter e fornecer informações úteis para a tomada de decisão. Dessa forma a avaliação serve de guia para a tomada de decisões na estruturação dos cursos e também no trabalho das disciplinas, que estão diretamente voltadas à aprendizagem dos estudantes.

A partir dessas suposições, algumas mudanças em relação ao processo de avaliação devem fazer parte das reflexões de professores e alunos dos cursos de engenharia, pois a avaliação está mudando, de atividade apenas centrada no professor e realizada no final das disciplinas, para a avaliação também centrada no aluno e na aprendizagem como parte integrada do currículo (Anastasiou & Alves, 2007). Inserir o aluno no processo de avaliação é uma maneira de aumentar a responsabilidade pela aprendizagem e ajudá-los a desenvolver habilidades de reflexão crítica e comunicação.

A avaliação deve se preocupar com o processo de apropriação dos saberes pelo aluno, com os diferentes caminhos que este percorre, mediados pela intervenção ativa do professor. Avaliar não é algo simples, e nas mais diversas experiências de aprendizagem ativa, nas quais se inclui o PBL e o PjBL, a avaliação da aprendizagem aparece como um ponto que desperta a atenção de professores e pesquisadores da Educação em Engenharia, como se depreende de (Villas-Boas, Mattasoglio Neto, Campos, & Aguiar Neto, 2012).

A melhoria no processo de ensino-aprendizagem nos cursos de engenharia depende da reestruturação do processo de ensino e da melhor definição dos instrumentos de avaliação da aprendizagem. Essa reestruturação depende da capacitação do corpo docente para a preparação de estratégias de ensino que atendam as diversas dimensões de aprendizagem e do envolvimento do corpo discente, para que se coloque como protagonista desse processo.

3 Metodologia

Com o objetivo de identificar a percepção dos professores sobre o processo de avaliação bem como identificar instrumentos que possam ser utilizados para avaliar as competências transversais desejáveis na formação do estudante de engenharia, realizou-se um *workshop* no qual foram colhidos dados a partir de um trabalho realizado com esses professores. Participaram um total de 68 professores em 2 *workshops*, um com 44 e outro com 14 participantes. Vale ressaltar que esses professores, muitas vezes engenheiro por formação, não tem conhecimentos sobre aspectos pedagógicos que permeiam a atividade docente. Esse fato gera grande defasagem entre os objetivos propostos e os realmente alcançados em um curso superior.

Nesses *workshops* participaram, essencialmente, professores que oferecem projetos aos estudantes do curso de engenharia. Esses projetos não estão relacionados diretamente às disciplinas do curso, mas são atividades complementares obrigatórias, oferecidos nas três primeiras séries do curso. Os estudantes escolhem esses projetos, dentro de um cardápio, com quase uma centena de opções. Não há restrição para a realização dos projetos, podendo estudantes de quaisquer séries participar de quaisquer projetos oferecidos. O maior problema encontrado nesse processo, e que motivou este trabalho de pesquisa, é o fato de que na grande maioria das vezes, os estudantes são avaliados apenas pela sua presença e participação no projeto. O objetivo do *workshop* foi de sensibilizar os professores sobre a necessidade de se avaliar os estudantes para além de estar presente nas atividades, ao mesmo tempo buscou-se a criação de um critério de avaliação que fosse significativo para o grupo de professores.

Em ambos os *workshops* os trabalhos foram divididos em três etapas. Inicialmente levantou-se, com o uso do aplicativo *Kahoot*, as percepções desses professores em relação a avaliação e competências transversais. A partir dessa breve pesquisa foram levantados os conhecimentos prévios desse grupo de professores em relação aos assuntos a serem abordados.

Em uma segunda etapa foram discutidos conceitos de avaliação e levantou-se a questão de como avaliar as competências transversais em atividades que têm projetos como foco da atividade do estudante. Foi solicitado aos professores que identificassem quais competências transversais podem ser atingidas nos projetos que oferecem aos estudantes. Com essa questão esperava-se levantar informações sobre que tipo de competências são conhecidas e avaliadas pelos professores nos projetos que conduzem.

Na última etapa foram apresentadas as competências mais valorizadas em anúncios de jornais para a contratação de engenheiros (Lima, Mesquita, Rocha, & Rabelo, 2017). A lista formada pelas dez competências mais valorizadas serviu como base para essa etapa. Essas dez competências foram divididas, uma por equipe, que tiveram como tarefa construir uma rubrica para a avaliação da aprendizagem dessas competências.

4 Dados e Resultados

A partir da pesquisa inicial, levantou-se as percepções do grupo de professores em relação aos itens a serem abordados durante o trabalho (Quadro 2 e Quadro 3).

Quadro 2 – Percepções iniciais levantadas com o uso do aplicativo Kahoot – Questão 1

Pergunta	Respostas			
A sua atividade da PAE é:	Projeto 43%	Oficina 22%	Ambos 19%	NAP 16%

PAE – Projetos e Atividades Especiais / NAP – Não aplico PAE

Quadro 3 - Percepções iniciais levantadas com o uso do aplicativo Kahoot – Questões 2 a 6

Pergunta	Respostas			
	Sim	Não		NAP
Sua atividade tem um objetivo definido e claro?	84%	0%		16%
O seu aluno conhece, desde o início, o objetivo da atividade?	84%	0%		16%
Você faz algum tipo de avaliação na sua atividade?	67%	17%		16%
Caso você avalie, você fornece a seus alunos um *feedback* da avaliação?	60%	13%	Não avalio 16%	11%
Você sabe o que são Competências Transversais?	46%	21%	Tenho uma ideia 33%	

PAE – Projetos e Atividades Especiais / NAP – Não aplico PAE

Observa-se que menos da metade (46%) do grupo de professores pesquisados indicam saber o que são *Competências Transversais*. Embora 67% dos professores afirmarem que realizam algum tipo de avaliação, na grande maioria dos casos, essa avalição não passa de uma simples verificação de presença.

Como resultado da segunda etapa chegou-se ao seguinte conjunto de competências que podem ser desenvolvidas com o trabalho por projetos (Quadro 4).

Quadro 4 – Conjunto de competências que podem ser alcançadas nos projetos

Competências	Ocorrências	%	Classificação na tabela de Lima *et al* (2017)
Trabalho em equipe	6	20,7	3º
Senso crítico	5	17,2	19º
Capacidade argumentação / comunicação	3	10,3	4º
Autonomia	3	10,3	10º
Seleção de informação	2	6,9	16º
Saber enfrentar desafios	2	6,9	
Pro-atividade	2	6,9	
Gestão de pessoas	1	3,4	
Criar / inovar	1	3,4	17º
Produção / Interpretação de texto	1	3,4	4º
Organização	1	3,4	6º
Capacidade analítica	1	3,4	16º
Relação interpessoal	1	3,4	9º

Nota-se que existe relação entre as competências levantadas junto ao grupo pesquisado e as obtidas por Lima *et al* (2017), embora em ordem de preferência distinta. Merece destaque a competência *Senso Crítico* que para o grupo pesquisado é a segunda em importância e no levantamento feito por Lima *et al* (2017) aparece apenas em 19º lugar.

Com base nas dez competências mais importantes apontadas por Lima *et al* (2017), as equipes criaram rubricas para acompanhamento e avaliação da aprendizagem dessas competências. Aqui neste trabalho, são apresentadas (Quadro 5) apenas 3 dessas rubricas, escolhidas pela ordem de importância na classificação de Lima *et al* (2017).

Quadro 5 – Proposta de três rubricas criadas por equipes de professores

Trabalho em Equipe	Comunicação	Autonomia e Responsabilidade
1º para Lima et al (2017) e 3º nesta pesquisa	3º para Lima et al (2017) e 4º nesta pesquisa	4º para Lima et al (2017) e 10º nesta pesquisa
Foco no Objetivo Proposto *X* Objetivo Atingido. Avaliação por atingimento de metas – não numérica. Sugestão de avaliação: 1. Auto avaliação da equipe: 1.1. Avaliação realizada a cada 2 ou 3 semanas; 1.2. Cada integrante se auto avalia – contribuição individual; 1.3. Cada integrante avalia os colegas – contribuição da equipe. 2. Avaliação da equipe pelo professor: 2.1. Questionamentos individuais.	Avaliação de documentos escritos: relatórios, projetos, artigos, etc. Avaliação de apresentações orais. A avaliação oral e escrita pode ser feita utilizando *peer instruction* de acordo com o cronograma pré-estabelecido pelo professor.	Utilização de questionário direcionado para auto avaliação e avaliação de seus pares. O professor avalia o grau de dependência de cada componente do grupo.

Observa-se que a proposta de rubricas para avaliação das competências transversais, têm pouca acuidade além de não apresentarem com detalhes como serão realizadas a avaliação da aprendizagem das competências aprendidas pelos estudantes. Esses dados indicam a necessidade de se dar uma formação teórica aos professores sobre o que e como avaliar competências transversais através de rubricas.

O não conhecimento de como realizar a avaliação de estudantes nessas competências pode levar o professor a não fazê-la. Como consequência, esse professor deixará de dar *feedback* ao estudante sobre sua aprendizagem o que é um elemento importante no processo da avaliação formativa.

A continuidade do trabalho com os professores prevê um acompanhamento de suas ações para a implantação das rubricas nos projetos em que atuam. Essa continuidade tem por objetivo avaliar como esse esboço inicial de rubrica evoluiu ao longo do semestre letivo. Ao final do semestre está marcado um novo encontro no qual os professores apresentarão os resultados alcançados com a aplicação dessas rubricas.

5 Considerações Finais

A aplicação de rubricas na avaliação da aprendizagem das competências transversais é um instrumento que pode colaborar efetivamente como avaliação formativa, auxiliando o professor no acompanhamento do processo educacional, acompanhamento esse essencial segundo Araújo *et al* (2016). Em seu trabalho, Oliveira (2016), afirma que os métodos de avaliação devem relacionar os instrumentos utilizados, os recursos pedagógicos disponíveis e os métodos de ensino utilizados.

Os resultados da etapa um, indicam que há uma proximidade com os resultados encontrado por Lima *et al* (2017) sobre quais competências são importantes na formação do engenheiro. Essa proximidade existe mesmo tendo a pesquisa sido realizada em Portugal. Talvez esse fato explique a discrepância na ordem de valorização dessas competências.

Os resultados também indicam que deve haver uma intervenção para que os professores compreendam o significado de rubrica, como construí-las e como extrair desses instrumentos os melhores resultados possíveis, promovendo assim uma avaliação de qualidade como sugerida por Moreira *et al* (2015).

Como já citado, essa foi uma etapa inicial de abordagem do problema junto a um grupo de professores. Trabalhos futuros serão realizados com o objetivo de criar uma ferramenta e, consequentemente, uma mentalidade própria para avalição desses projetos e atividades.

6 Agradecimentos

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Development of Course Evaluation Matrices as a Learning Guideline Tool of Curricular Competences

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Abstract

Kroton Educacional is the world's largest private education company. In line with the guidelines of the Ministry of Education, which evaluates Brazilian students for competencies in all spheres of education, and in order to establish a formative and development evaluation process, Director of Assessment Academic developed matrices for the course evaluation of Accounting Sciences based on egress profile established in the National Curricular Directive. As a starting point, a course evaluation matrix was developed (based on the Pedagogical Project of the Course) guided by profiles and competences present in DCN and the National Student Performance Exam. Then, six test matrices were produced from the course matrix, thus guaranteeing the production of questions with contents surely already recognized by the students. To test the effectiveness of the assessment matrix in the 2017 (second semester), all students will perform the test formed by the knowledge objects that will evaluate technical and transversal competencies and, consequently, its reflection on the gradual composition of the professional profile. Besides to the challenge of ensuring that competences are incorporated and developed by our students throughout undergraduate education, in addition, the evaluation matrix allows to identify the gaps in the curricular matrix of the current academic model, providing indicators, actions and strategies that will substantially remedy the resources needed to form the expected egress profile.

Keywords: Evaluation Matrix; Learning Assessment; Technical Competencies; Transversal Competencies.

Desenvolvimento de Matrizes de Avaliação de Curso como Ferramenta Balizadora do Aprendizado das Competências Curriculares

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Abstract

A Kroton Educacional está entre as maiores empresas privadas no ramo da educação. Em consonância com as diretrizes do Ministério da Educação, que avalia os estudantes brasileiros por competências em todas das esferas do ensino, e visando estabelecer um processo de avaliação de caráter formativo e de desenvolvimento, a Área de Avaliação de Aprendizagem da Instituição canalizou esforços na construção de matrizes de avaliação do curso de Ciências Contábeis pautadas no perfil do egresso disposto na Diretriz Curricular Nacional (DCN). Como ponto de partida, foi desenvolvida uma matriz de avaliação do curso (a partir do Projeto Pedagógico do Curso) norteadas por perfis e competências presentes na DCN e no Exame Nacional de Desempenho de Estudantes (Enade). Em seguida, seis matrizes de provas foram geradas a partir da matriz de curso, garantindo assim, a produção de questões com conteúdos seguramente já reconhecidos pelos estudantes. Para testar a eficácia da matriz de avaliação, no segundo semestre de 2017, todos os alunos do curso de Ciências Contábeis da Instituição realizarão provas constituídas por objetos de conhecimentos que avaliarão competências técnicas e transversais e, consequentemente, o seu reflexo na composição gradual do perfil profissional. Além do desafio de garantir que as competências, em sua totalidade, sejam incorporadas e desenvolvidas pelos nossos estudantes ao longo do ensino superior, adicionalmente, a matriz de avaliação permite identificar as lacunas presentes na matriz curricular do modelo acadêmico da Instituição, oportunizando indicadores, ações e estratégias que remediarão substancialmente os recursos necessários para formação do perfil do egresso esperado.

Keywords: Matriz de Avaliação; Avaliação de Aprendizagem; Competências Técnicas; Competências Transversais.

1 Introdução

Em consonância com as diretrizes do Ministério da Educação, que avalia os estudantes brasileiros por competências em todas das esferas do ensino, e visando estabelecer um processo de avaliação de caráter formativo e de desenvolvimento, bem como, uma apreciação qualitativa sobre dados relevantes do processo de ensino e aprendizagem, a área de Avaliação de Aprendizagem da Instituição canalizou esforços na construção de matrizes de avaliação por competência, pautadas no perfil do egresso disposto na Diretriz Curricular Nacional (DCN) e no Exame Nacional de Desempenho de Estudantes (Enade).

A garantia dos padrões de qualidade aos processos avaliativos é fundamentalmente importante, de modo que se tenha verificação controlada e afinada de competências e habilidades previstas no perfil profissional do egresso de cursos de Educação Superior. Ressalta-se ainda que tal cuidado tem, portanto, implicações diretas sobre a empregabilidade dos egressos.

Assim, a matriz de competência é uma ferramenta de pesquisa acerca dos recursos ou competências, envolvendo aspectos que vão do individual ao sociocultural, situacional (contextual-organizacional) ao processual. A avaliação de competências através da matriz produzirá indicadores que articulem as dimensões: educacional, profissional e sociopolítica.

2 Referencial Teórico

O desenvolvimento de um perfil profissional competente e comprometido com as demandas sociais é um processo longo, pois envolve a construção de uma história profissional, articulada às características pessoais e às especificidades do exercício profissional, requerendo o desenvolvimento de competências que permitam considerar e articular teorias, métodos e experiências no mapeamento e na resolução dos problemas no cotidiano social e laboral (Marinho-Araujo & Almeida, 2016).

Para a construção desse perfil profissional, atuante e participativo, as trajetórias de formação têm utilizado a abordagem por competências como estratégia privilegiada e útil tanto ao desenvolvimento pessoal quanto à preparação para os papéis e funções a serem desempenhados nos contextos de atuação profissional. No Brasil, as Diretrizes Curriculares Nacionais para todos os cursos de graduação utilizam essa abordagem como referência básica para a organização e o desenvolvimento curricular dos referidos cursos (Brasil, 2003). Trabalhar competências como uma estratégia de construção do perfil educacional ou profissional esperado apresenta-se como ferramenta bastante útil à complementação da formação na educação, mas, em contrapartida, oferece alguns desafios, especialmente quanto à avaliação desse desenvolvimento (Marinho-Araujo & Rabelo, 2015).

Competência pode ser definida como a mobilização, de forma articulada e interdependente, de diversos recursos disponíveis ao estudante e em seu contexto atitudinal, que deverão ser articulados aos pontos críticos diante de uma situação problema, possibilitando a tomada de decisões, encaminhamentos adequados e úteis a seu enfrentamento, em contextos sociais e laborais. Ao mesmo tempo, a dinâmica do desenvolvimento de competências, as mediações socioafetivas, a influência do contexto e das relações devem ser consideradas tanto no momento interpretativo do processo avaliativo quanto, antes, na elaboração dos instrumentos que irão apontar os indicadores acerca de futuros desenvolvimentos de competências (Marinho-Araujo & Almeida, 2016).

As competências transversais são entendidas como um conjunto diversificado de recursos individuais e socioculturais, mobilizados com intencionalidade pelos sujeitos em situação de formação ou exercício profissional, visando à resolução de uma determinada situação problema. Essas competências pressupõem a integralidade das dimensões cognitivas, emocionais e sociais, articuladas ao conhecimento teórico formal na formação de trajetórias profissionais cada vez mais complexas; englobam um conjunto diversificado de recursos pessoais, princípios éticos e escolhas estéticas transversais às diferentes profissões e atividades profissionais (Cabral-Cardoso, Estevão & Silva, 2006; LeBoterf, 2000, 2003; Marinho-Araujo, 2009, 2014, 2015; Zarifian, 2001, 2003).

Fundamentada nos pressupostos teóricos do pensamento crítico-dialético, essa matriz concebe a noção de competência como multidimensional, envolvendo facetas que vão do individual ao sociocultural, situacional (contextual-organizacional) e processual. O desenvolvimento e a avaliação de competências educacionais e profissionais, nessa perspectiva, são balizados por parâmetros socioculturais e históricos, referindo-se primordialmente aos contextos, espaços e tempos e ancorados em dimensões macrossocioculturais de classe social, gênero, etnias, grupos geracionais (Deluiz, 2001).

As contribuições teóricas acerca da matriz de competências, defende-se sua utilização como instrumento avaliativo, especialmente quando a avaliação focaliza contextos educacionais amplos, como programas ou sistemas de ensino. Operacionalmente, a matriz deve ser construída tendo como base fundamental o perfil de formação esperado. O perfil pode ser elaborado a partir da literatura ou de análises, estudos e categorizações originadas em documentos, projetos, legislação. Entrevistas, observações e outras metodologias podem também subsidiar a construção do perfil. A partir da definição do perfil, identificam-se os recursos a serem mobilizados para a construção das competências esperadas (Marinho-Araujo & Rabelo, 2015).

Esses componentes irão fundamentar a matriz de referência a partir de uma concepção tridimensional: seu desenho é composto por colunas verticais e linhas horizontais que se cruzam em quadrículas denominadas de células. Nas linhas, distribuem-se as características condizentes ao perfil esperado; nas colunas, disponibilizam-se os diversos recursos a serem avaliados que, mobilizados em processos educacionais e de formação profissional, compõem as competências: conhecimentos, saberes, escolhas éticas e estéticas, habilidades, posturas etc (Marinho-Araujo & Rabelo, 2015).

Tais recursos podem ser categorizados em grandes blocos, que poderão sinalizar aspectos do contexto, das relações, das metas institucionais, orientados pelas características do perfil a ser formado. As células de interligação sintetizam os objetos da avaliação ou as atividades exercidas, permitindo o cruzamento dos perfis com os diversos recursos mobilizados. Com esse desenho, a matriz constitui-se como referência para elaboração de instrumentos avaliativos ou, ainda, para promover orientações e feedback nas trajetórias profissionais formativas, quer seja para os próprios participantes da avaliação, para gestores ou para fomentar ações macropolíticas. A partir da compreensão de competências, a metodologia multidimensional da matriz de referência para, a partir do perfil esperado, identificar os recursos que compõem as competências, envolvendo facetas que vão do individual ao sociocultural, situacional (contextual, organizacional) e processual. A avaliação de competências com base na matriz pode servir como instrumento investigativo que articula dimensões educacional, profissional e sociopolítica (Marinho-Araujo & Rabelo, 2015).

Para a construção de um instrumento avaliativo, a matriz é o ponto inicial da metodologia, que perpassa pela construção de uma avaliação objetiva para uso em larga escala aos estudantes da instituição. Essa avaliação compreende mobilizar as competências a serem desenvolvidas a partir de uma situação problema que permita ao estudante articular recursos, como conhecimentos, comportamentos e para solucionar a questão a partir desse novo desafio. Ao mobilizar essas competências na avaliação, é possível perceber a construção do perfil esperado para o egresso do curso (Marinho-Araujo & Rabelo, 2015).

> A avaliação de competências orientada pelo perfil profissional desejado, em contraponto à mensuração do desempenho de tarefas, mostra-se igualmente útil para o planejamento, coordenação e acompanhamento de ações, tanto por parte dos sujeitos avaliados quanto para auxiliar ações ampliadas e políticas educacionais. (Marinho-Araujo & Rabelo, 2015, p. 456).

Assim, será possível a partir dessa avaliação, construir a evolução de desenvolvimento do estudante, permitindo a ele, buscar desenvolver aquilo que se faz necessário, quanto a criação de um plano de ação para a instituição, revendo suas práticas, modelos e organizações pedagógicas, permitindo uma melhoria contínua no currículo ofertado.

3 Metodologia

A construção da matriz de avaliação teve como embasamento o Projeto Pedagógico do Curso (PPC) de Ciências Contábeis da Instituição, que estão alicerçadas nos perfis e competências das Diretrizes Curriculares Nacionais (DCN) e no Exame Nacional de Desempenho de Estudantes (Enade).

A matriz de curso é o alicerce para as matrizes de prova, pois, através da matriz de curso, podemos desenvolver matrizes por série, por período, por carga horária, entre outras.

Assim, foram definidas etapas da construção da matriz de avaliação de Ciências Contábeis e estendido aos cursos de Engenharias e bacharelados na área de Exatas.

Inicialmente, foi preciso um estudo referente ao perfil e as competências descritas na DCN e na Portaria do Enade do curso de Ciências Contábeis.

Foi realizado um desenho metodológico, através da transcrição dos perfis e competências para a matriz. Os perfis são destacados e organizados, de foram que possam ser cruzados com as competências, técnicas e transversais previstas para o curso.

Dado o perfil de egresso, esperado pelo estudante, se faz necessário conhecer quais as competências são fundamentais para a construção das características dos alunos. Esta etapa é fundamental para a construção da matriz de forma adequada. É neste momento que há uma apreciação da relação entre o perfil desejado e o conjunto de recursos necessários para a construção das competências.

Também foram relacionados os objetos de conhecimentos (conteúdos, temas, disciplinas, etc), identificados por meio da DCN, Enade e disciplinas oferecidas pela Instituição, necessários para o desenvolvimento das competências, pré-identificadas e relacionadas com as características esperada pelo estudante na sua formação.

Em seguida, a matriz foi revisitada para uma nova observação da relação do perfil, competência e objeto de conhecimento. Essa analogia é a base para a criação das questões da avaliação, e deve ser instrumento de mediação, ser intencional e deve mostrar o perfil que queremos formar.

Nesse momento, temos um mapeamento do que é esperado como característica dos estudantes ao se formar, quais as competências necessárias para a formação dessas características e ainda quais recursos serão utilizados para desenvolvimento dessas competências, tudo em consonância com o marco regulatório e a proposta pedagógica do curso.

Temos como exemplo um cruzamento de perfil e competências técnicas da matriz do curso de Ciências Contábeis:

Perfil: Aptidão para manifestar capacidade crítico-analítica, inclusive em atividades de apurações, auditorias, perícias, arbitragens e quantificações de informações financeiras, patrimoniais públicas e privadas, para os usuários da informação contábil.

Recursos: Construir pareceres e relatórios que contribuam para o desempenho da gestão dos usuários da informação contábil, quaisquer que sejam os modelos organizacionais.

Temos também, um exemplo de perfil e competências transversais para a mesma matriz:

Perfil: Atuação pautada na ética profissional e com responsabilidade socioambiental.

Recurso: Gerar informações para a organização de atitudes e construção de valores orientados para a cidadania.

Nos dois exemplos de cruzamentos, temos que levar em consideração que, para o estudante atingir o perfil escolhido, é necessário o desenvolvimento dessas competências.

Em seguida, vamos tomar como referência o perfil e a competência técnica apresentada anteriormente. Para que o estudante alcance o perfil de ter aptidão para manifestar capacidade crítico analítica nas atividades contábeis, é necessário desenvolver a competência de construir pareceres e relatórios que contribuam para o desempenho da gestão dos usuários da informação contábil.

E para que se alcance esse perfil e essa competência, é imprescindível que o estudante conheça os seguintes temas: Contabilidade Financeira e Societária, Noções de Atuária, Contabilidade Pública, Auditoria e Perícia Contábil.

Depois de concluída essa etapa, foram avaliadas as questões dos três últimos Enade (2009, 2012 e 2015) do Curso de Ciências Contábeis. Ainda esta etapa concerne na identificação dos conteúdos cobrados na prova, bem como na estrutura da questão e, principalmente, nas situações problemas contidas nos itens. Também utilizamos o Relatório Síntese de Área do Enade 2015 de Ciências Contábeis e examinamos o cruzamento das características de perfil, recursos (competências) e objetos de conhecimento utilizados na prova.

Após a análise dos sentidos e significados e a verificação das provas do Enade, foram realizados os ajustes, inclusões de outras características ou ainda detalhamento das já existentes, necessários na matriz de curso e criamos a partir desta, as matrizes de avaliação. As matrizes de avaliação são organizadas em níveis, diferenciadas para alunos do início, meio e fim do curso. Todas as matrizes de avaliação compreendem a matriz do curso completa.

Em seguida, são criadas as questões, a partir de uma situação problema, que mobilize a competência definida na matriz para construção do perfil do egresso desse cruzamento. São construídas, provas objetivas para serem realizadas por todos os estudantes do curso, visando acompanhar o estudante desde o ingresso até a conclusão do curso, para verificar o contexto social, as habilidades, competências, aprendizagem e, principalmente, identificar a condição pessoal, profissional e os déficits de aprendizagem dos nossos estudantes.

Essas avaliações objetivas são aplicadas semestralmente aos estudantes dos cursos, conforme calendário acadêmico. Ao longo do tempo, poderá ser analisada o desenvolvimento do estudante, acompanhando sua evolução desde as séries iniciais, até o final do curso superior. Com isso, é possível fazer inferências ainda durante o processo de realização do curso, bem como, buscar melhorias estruturais para os novos estudantes.

4 Conclusão

A utilização da metodologia de matrizes de avaliação para elaboração de provas é essencial para identificação dos objetivos da prova, organizando num único instrumento perfis e competências a serem verificados na avaliação. Esse instrumento ainda gera indicadores de diferentes níveis de dificuldades, identificando os estudantes a partir dos seus resultados e mostrando os diferentes resultados esperados numa questão da avaliação.

Além do desafio de garantir que as competências, em sua totalidade, sejam incorporadas e desenvolvidas pelos nossos estudantes ao longo do ensino superior, adicionalmente, a matriz de avaliação permite identificar as lacunas de aprendizagem dos estudantes submetidos a essas avaliações, buscando assim retroalimentar a cadeia de identificação das necessidades e características previstas nos cursos oportunizando indicadores, ações e estratégias que remediarão substancialmente os recursos necessários para formação do perfil do egresso esperado.

A matriz, quando construída de forma organizada para o curso, pode gerar subsídios para qualquer avaliação de aprendizagem a ser desenvolvida, sendo um recurso de planejamento ao professor.

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PAEE/ALE'2018 Full Papers Submissions (Spanish)

Submissions accepted for the PAEE/ALE'2018 papers sessions in Spanish.

Disciplinary and Generic Abilities in PBL: A Study of Life Stories from the Gender Perspective in Systems Engineering Education

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Abstract

While it is true that socio-economic environment plays a determining role in terms of gender and entry into technological careers such as systems engineering, tendency to generate generic and disciplinary competencies from the gender point of view, is also something relevant to analyze specific actions that allow curricular changes in curricula. Recent studies show a reduction in the entry of women into systems engineering careers since several years ago. Some of these studies suggest, among other things, aspects of socio-economic perception to explain this phenomenon. In this research we want to offer a new angle of debate focused on the results of the training process by using PBL case of study in Systems Engineering grade. We were interested in exploring the generation of competencies by gender. The Tuning Latin America project, which was originated in its European counterpart, represented an effort to locate generic and disciplinary competencies of computer science practitioners with the participation of 14 universities in the region. In this study we explore the state of internalization of disciplinary and generic skills in systems engineering students based on their life histories by considering the gender perspective. The main research method used was content analysis of approximately 150 life histories of systems engineering students. Previously, a set of disciplinary and generic skills was defined based on the classification of such skills included in the Tuning Latin America project. Interviews and focus groups sessions were also used in order to validate information. The results indicate several interesting aspects. The main competence identified by men is the disciplinary competence "Apply knowledge of computer science" and for women it was a generic competence called "the teamwork ability". The results also show evidence that the PBL and management by competencies can help visibility of competencies something that regular Systems Engineering students would not consider, especially in the case of men, who in spite of consider first some disciplinary competences, they tend to put other generic competencies in second place. This aspect, which seems not related to gender stereotypes, could also be other attractive factor to motivate women to enter Systems Engineering education. Finally, this study not only points out the differences, but also the common elements in the teaching-learning process of engineering, such as the balance between both groups of competencies. Both male and female students using the PBL and a competencies approach, show the importance of a balance between technical and generic skills, a situation that guarantees job and social integration for future professionals.

Keywords: Soft andTechnical Skill, Skills and PBL, Skills by gender, System Engineering Education.

Habilidades Disciplinares y Genéricas en PBL: Un Estudio de Historias de Vida desde la Perspectiva de Género en Educación de Ingeniería de Sistemas

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Resumen

Si bien es cierto el entorno socio-económico juega un rol determinante en cuanto al género y el ingreso a carreras tecnológicas como la ingeniería de sistemas, la predisposición a la generación de competencias genéricas y disciplinares desde el punto de vista de género, es también algo relevante a la hora de analizar acciones específicas, que permitan realizar cambios curriculares en los planes de estudio. Estudios recientes, muestran la disminución desde hace varios años del ingreso de mujeres a las carreras de ingeniería de sistemas. Algunos de estos estudios sugieren, entre otras cosas, aspectos de percepción socio-económicos que explican el fenómeno. En esta investigación queremos ofrecer un nuevo ángulo de debate, desde la perspectiva de género, concentrado en los resultados del proceso de formación, en un contexto de aplicación de PBL para el caso de una carrera universitaria en Ingeniería de Sistemas. Específicamente, nos interesó explorar la generación de competencias por género. El proyecto Tuning Latinoamérica originado en su homólogo europeo, representó un esfuerzo para ubicar competencias genéricas y disciplinarias de los profesionales en el área de informática, con la participación de universidades de 14 países del área. En el presente estudio se explora el estado de interiorización de habilidades disciplinarias y genéricas desde la perspectiva de género en estudiantes de ingeniería de sistemas a través de sus historias de vida. Se realizó como método principal de investigación el análisis de contenido de 147 historias de vida de estudiantes de la carrera de ingeniería de sistemas. Se definieron categorías apriorísticas basadas en la clasificación del proyecto Tuning Latinoamérica. Como métodos de validación se realizaron entrevistas y focus group con los estudiantes egresados de los cursos. Los resultados indican aspectos interesantes. La principal competencia identificada por los hombres es la competencia disciplinaria "Aplicar el conocimiento de ciencias de la computación" y por parte de las mujeres fue una competencia genérica la "Capacidad de trabajo en equipo". Se muestra evidencia que el PBL y la gestión por competencias facilita la visibilidad de competencias que tradicionalmente estudiantes de ingeniería de Sistemas no valorarían, especialmente los hombres, que a pesar de considerar en primer lugar algunas competencias disciplinarias colocan otras genéricas en segundo lugar. Este aspecto, que parece alejado de los estereotipos, también podría ser un factor atrayente para que las mujeres se motiven a ingresar a carreras de Ingeniería de Sistemas. Finalmente este estudio, no solo señala las diferencias, sino los elementos comunes en el proceso de enseñanza aprendizaje de las ingenierías, como son el balance entre ambos grupos de competencias, genéricas y disciplinarias. Los estudiantes tanto hombres como mujeres utilizando el PBL y una orientación por competencias evidencian la importancia de un balance entre habilidades técnicas y genéricas, situación que garantiza una inserción laboral y social para los futuros profesionales independiente del género.

Keywords: Soft andTechnical Skill, Skills and PBL, Skills by gender, System Engineering Education.

1 Introducción

La necesidad de la fuerza laboral y aporte social que representan las mujeres son aspectos que tienen implicaciones familiares, sociales y económicas (Bustos, 2008), el papel de las universidades en estos temas requiere de un conocimiento sobre las situaciones que facilitan o impiden el desarrollo, de una manera inclusiva, de todos los sectores de la sociedad.

La educación de la ingeniería y específicamente de la ingeniería de sistemas desde la perspectiva de género, se ha venido explorando desde hace algunos años. Resultado de ello, se visualiza la necesidad de eliminar obstáculos que tienen las mujeres con respecto a su desarrollo integral, ya sean producto de acciones conscientes o por factores culturales. Por ejemplo, como menciona (Bustos, 2008), "la ausencia de equidad entre mujeres y hombres en los planes de estudios de la educación superior".

El conocimiento en la forma en que se desarrollan competencias, es sin duda una de las mayores preocupaciones de la educación superior en la actualidad (Andrews, 2008)(Noll, 2002). Específicamente, la disminución en el ingreso de mujeres en las carreras de Ingeniería de Sistemas (Mora-Rivera, 2017), la evidencia de la necesidad de incorporar los aportes asociados con cada género, así como las distinciones culturales, raciales y de género se convierten en elementos clave para realizar mejoras en programas y planes de estudio (Leggon, 2010). Este conocimiento además permite la definición de funciones en el campo laboral, aporte económico y desarrollo social.

Si bien es cierto que el entorno socio-económico juega un rol determinante en cuanto al género y el ingreso a carreras tecnológicas como la ingeniería de sistemas, la predisposición a la generación de competencias genéricas y disciplinares desde el punto de vista del género, es también algo relevante a la hora de analizar acciones específicas que permitan realizar cambios curriculares en los planes de estudio.

Se presenta a continuación el análisis de contenidos de historias de vida de estudiantes de la carrera de ingeniería de sistemas cuyo propósito fue determinar desde la perspectiva de género la forma en que los estudiantes perciben el desarrollo de competencias genéricas y disciplinarias, en cursos de ingeniería de sistemas, donde la metodología de enseñanza aprendizaje está basada en el PBL (Project Based Learning por sus siglas en inglés) y en el desarrollo de competencias. Las competencias seleccionadas se basan en la clasificación establecida en el proyecto Tuning Latinoamérica para el área de informática (Contreras, 2013).

Inicialmente se hace un acercamiento al proyecto Tuning para Latinoamérica que representa un esfuerzo de universidades de 14 países de la región, seguido se desarrolla el tema de PBL y educación por competencias, sus beneficios en la educación superior y la relación con el género, luego se describe el marco metodológico de la investigación, seguidamente se muestran los principales resultados y finalmente las conclusiones y trabajos futuros.

5.1 Proyecto Tuning Latinoamérica

El proyecto Tuning (González J, 2003), nace en Europa en el año 2000, lo que motivó en América Latina el desarrollo de un estudio similar que incluyó el área de informática (Contreras, 2013), el cual contó con la participación de diferentes universidades de 14 países. Uno de sus resultados fue la generación de competencias genéricas y disciplinarias como parte del meta perfil del área de informática, convirtiéndose en un referente importante para la región.

Las competencias se definen desde la perspectiva de los resultados de aprendizaje como "conocimientos, habilidades, actitudes y responsabilidades, que describen los resultados del aprendizaje de un programa educativo o lo que los alumnos son capaces de demostrar al final del proceso educativo" (González J, 2003) citado en (Aquilino, 2006).

5.2 Desarrollo de competencias en la Cátedra de Ingeniería de Sistemas de la Universidad Nacional de Costa Rica.

La cátedra de ingeniería de sistemas de la UNA (Universidad Nacional de Costa Rica) está conformada por estudiantes y profesores de 3 tipos de cursos de Ingeniería de Sistemas: I, II y III. Como estrategia fundamental de enseñanza aprendizaje se utiliza desde hace más de 10 años el PBL (Sandoval-Carvajal, 2017). La población promedio por generación es de 120 estudiantes en la sede central y 30 para la sede interuniversitaria.

Durante estos 3 cursos los estudiantes desarrollan un proyecto de ingeniería de sistemas para una empresa real, inician con una propuesta y se realizan las etapas de definición del alcance, definición de requerimientos, análisis, diseño, codificación, pruebas e implementación.

Luego de un estudio donde se llevó a cabo un análisis de las necesidades de la industria (Macaya, 2006)(Mata, 2003) y la academia, con miras a fortalecer el perfil del egresado de los cursos y su inserción en el campo laboral y social, desde el año 2008 la Cátedra de Ingeniería de Sistemas definió 3 áreas en el desarrollo de competencias: Ingeniería de Sistemas, Administración de Proyectos y Habilidades Blandas. (Cortés, 2015)

6 PBL, educación por competencias y género.

La evaluación de competencias, tanto en el aspecto laboral como en las carreras de ingeniería de sistemas, es actualmente una tarea crítica en búsqueda del rendimiento académico y de la inversión en TI (Colomo-Palacios, 2013). Estas competencias no deben limitarse solo a las relacionadas con la disciplina, sino aquellas denominadas blandas (Andrews, 2008) (Aquilino, 2006) o genéricas (Contreras, 2013). No debe dejarse de lado el contexto, ya que existe evidencia sobre los estereotipos de profesiones, estilos de aprendizaje, competencias y otros; por ejemplo, que las ingenierías son para los hombres, que la enfermería y educación que son más de enfoque de servicio, son para las mujeres (Cubillas, 2016) (White, 2006).

Como mencionan Hazzan & Hadar (2008) y Colomo-Palacios (2013) el componente social y humano es un factor determinante en el éxito de los proyectos asociados a las Tecnologías de Información (TI) y específicamente en el desarrollo de software. Este componente social en el desarrollo de software coloca en competencias genéricas, el manejo de conflictos, comunicación efectiva, creatividad, organización y trabajo en equipo como habilidades claves, tanto en el ámbito local como global (Fernández-Sanz, 2012).

Múltiples estudios muestran los resultados positivos de la aplicación del PBL en carreras de ingeniería (Guerra, 2017) (Radcliffe, 2016) (Cortés, 2015), no solo en el desarrollo de tareas específicas de la ingeniería, sino en la motivación y compromiso de los estudiantes, aun cuando esta metodología requiere más dedicación que las clases y métodos tradicionales (Rodríguez, 2015).

A través de la utilización de PBL, estudios empíricos sugieren que la contextualización de ambientes de aprendizaje puede lograr mayor motivación para la participación de las mujeres en carreras de ingeniería, siendo necesario realizar modificaciones en el modelo de enseñanza de la ingeniería (Xiangyun, 2009)(Kolmos, 2013), por lo que conocer acerca de las formas de desarrollo o percepción de los estudiantes sobre sus competencias, podría aportar elementos claves para cambios en la igualdad y equidad de género en la educación de las ingenierías.

7 Enfoque metodológico

La pregunta de investigación del presente estudio fue ¿Cómo las historias de vida de estudiantes de ingeniería de sistemas, muestran el desarrollo de competencias genéricas y disciplinarias desde la perspectiva de género?

Para ello, se realizó como método principal de investigación el análisis de contenido de aproximadamente 147 historias de vida de estudiantes de la carrera de ingeniería de sistemas, que representan el 98% de la población de estudiantes. La pregunta base para el desarrollo de las historias de vida por parte de los estudiantes fue "¿Qué aprendí en los cursos de Ingeniería de Sistemas I,II y III". La longitud de los documentos fue en un promedio de 4 páginas.

El modelo de historias de vida (McAdams, 2001) se basa en el hecho de que las personas que viven en las sociedades modernas desarrollan sus vidas con una unidad y propósito para construir internamente una narrativa evolutiva del mismo. Esta técnica facilita a los individuos expresar en sus propias palabras sus historias de vida individuales, lo que permite, ya de forma colectiva, entender mejor cómo funcionan los individuos y el ambiente en las cuales ellos se contextualizan.

Asimismo, esta técnica permite al investigador comprender mejor los esquemas interpretativos de los individuos en sus diferentes roles. El método de historias de vida, complementa a los numerosos estudios de cultura organizacional, en el análisis cultural de la complejidad y dinamismo del contexto, por medio de un abordaje individual (Cassell, 2004).

Luego de un análisis comparativo se homologaron las competencias definidas para la cátedra de Ingeniería de Sistemas (Cortés, 2015)y las establecidas en el proyecto Tuning para Latinoamérica para el área informática (Contreras, 2013) (ver Tabla 2. Cantidad de competencias referenciadas por sexo Femenino.) Se definieron éstas como categorías apriorísticas divididas de acuerdo a Tuning en disciplinarias y genéricas. Las competencias transversales a todo el plan de estudios que además coinciden con Tuning y el modelo pedagógico de la Universidad (UNA, 2012), no se consideraron parte de este estudio, por ejemplo compromiso con la preservación del ambiente o valoración y respeto por la diversidad y la multiculturalidad, entre otras.

Para el análisis de las historias de vida se utilizó el software denominado NVIVO®, un software que facilita el análisis de datos cualitativos. NVIVO® permite a medida que se analizan los documentos codificar de acuerdo a las categorías, para nuestro caso en disciplinarias y genéricas, además los documentos se clasificaron por género. Finalmente se generan informes cuantitativos sobre la cantidad de referencias, ver Figura 14 Sesión típica de NVIVO® durante el análisis de contenido.

Cómo métodos de validación se realizaron entrevistas y focus group con estudiantes egresados de los cursos que son parte de la población estudiada. Los participantes finalizaron el bachillerato y actualmente se encuentran trabajando. Los objetivos de la triangulación fueron validar los resultados del análisis de contenidos y profundizar en las posibles razones de los principales hallazgos.

7.1 Aspectos demográficos

La Escuela de Informática de la Universidad Nacional (Costa Rica) cuenta con aproximadamente 1500 estudiantes en la carrera de Ingeniería de Sistemas, la población de mujeres admitidas en la carrera es en promedio de un 18% (Mora-Rivera, 2017). La cátedra de ingeniería de sistemas la conforman estudiantes y profesores de los cursos Ingeniería de Sistemas I,II y III.

Las historias de vida analizadas corresponden al 98% de la población de la Cátedra de Ingeniería de Sistemas. La edad promedio de los estudiantes es 21 años, se encuentran en el cuarto año de la carrera, a un semestre de la finalización del bachillerato. En promedio el 16% de los estudiantes de la cátedra son mujeres. (Ver Tabla 1Cantidad de estudiantes por sexo participantes en el estudio)

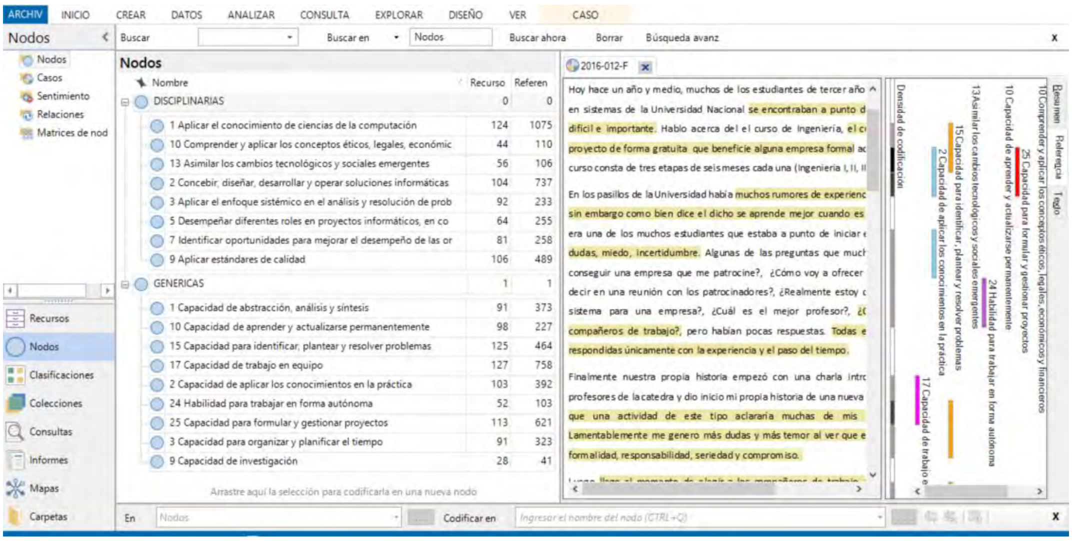

Figura 14 Sesión típica de NVIVO® durante el análisis de contenido.

7.2 Consideraciones éticas

Los estudiantes firman una carta de intenciones al inicio del curso Ingeniería de Sistemas I, donde autorizan la utilización de información para estudios académicos. Igualmente firmaron un formulario de consentimiento para el focus group. Los nombres de los estudiantes se eliminaron de las historias de vida y se codificaron con una numeración secuencial, diferenciando únicamente entre hombres y mujeres.

Tabla 1 Cantidad de estudiantes por sexo participantes en el estudio

Género	Cantidad	Porcentaje (%)
Masculino	123	84
Femenino	24	16
Total	147	100

7.3 Limitaciones

Para minimizar el efecto subjetivo del análisis de contenidos por parte de los investigadores, se realizaron sesiones de definición de competencias, llevándose a cabo una prueba piloto y taller para consensuar criterios en la evaluación individual de los casos y codificación de las categorías.

8 Resultados

8.1 Resultados del Análisis de contenido de historias de vida

De acuerdo a la Tabla 2 y Tabla 3 la principal competencia identificada por las mujeres fue una competencia genérica: Capacidad de trabajar en equipo (15%) mientras que para los hombres fue una competencia disciplinaria "Aplicar el conocimiento de ciencias de la computación" (13%).

Tomando en cuenta cada categoría coincide, tanto para hombres como para mujeres, que la competencia disciplinaria de mayor valor fue: Aplicar los conocimientos en Ciencias de la Computación y para las competencias genéricas fue la Capacidad de Trabajo en Equipo. Ver Tabla 2. Cantidad de competencias referenciadas por sexo Femenino y Tabla 3 Cantidad de competencias referenciadas por sexo Masculino.

Tabla 2. Cantidad de competencias referenciadas por sexo Femenino

	Cantidad	%
COMPETENCIAS DISCIPLINARIAS		
Aplicar el conocimiento de ciencias de la computación	202	28,77
Concebir, diseñar, desarrollar y operar soluciones informáticas	176	25,07
Aplicar estándares de calidad	112	15,95
Desempeñar diferentes roles en proyectos informáticos, en contextos multidisciplinarios y multiculturales, tanto locales como globalizados	91	12,96
Identificar oportunidades para mejorar el desempeño de las organizaciones	49	6,98
Aplicar el enfoque sistémico en el análisis y resolución de problemas	31	4,42
Comprender y aplicar los conceptos éticos, legales, económicos y financieros	27	3,85
Asimilar los cambios tecnológicos y sociales emergentes	14	1,99
TOTAL COMPETENCIAS DISCIPLINARIAS	702	100
COMPETENCIAS GENERICAS		
Capacidad de trabajo en equipo	225	28,70
Capacidad para formular y gestionar proyectos	126	16,07
Capacidad para identificar, plantear y resolver problemas	99	12,63

Capacidad de abstracción, análisis y síntesis	95	12,12
Capacidad de aplicar los conocimientos en la práctica	83	10,59
Capacidad para organizar y planificar el tiempo	69	8,80
Capacidad de aprender y actualizarse permanentemente	45	5,74
Habilidad para trabajar en forma autónoma	35	4,46
Capacidad de investigación	7	0,89
TOTAL COMPETENCIAS GENERICAS	784	100

Las mujeres muestran el mismo porcentaje, cerca de 28% para los primeros lugares en ambas categorías genéricas y disciplinarias, mientras que los hombres los primeros lugares son ocupados por las competencias disciplinarias.

Como se muestra en la Tabla 4 Total de referencias por categoría por sexo, los hombres muestran un porcentaje similar (50,48 y 49,52) para ambas categorías disciplinarias y genéricas, mientras que las mujeres tienen un 7 % más para las genéricas que en las disciplinarias (47,24 y 52,75)

8.2 Focus group y entrevistas

Se realizaron entrevistas con 2 estudiantes egresados de los cursos y un focus group, con la participación de 9 estudiantes igualmente egresados. Se consultó a los participantes sobre cuales competencias consideraban que más se desarrollan en los cursos de ingeniería de sistemas, para esta pregunta en particular los resultados coincidieron con el análisis de las historias de vida: mujeres Capacidad de trabajo en equipo y hombres: Aplicar el conocimiento de ciencias de la computación.

Tabla 3. Cantidad de competencias referenciadas por sexo Masculino

	Cantidad	%
COMPETENCIAS DISCIPLINARIAS		
Aplicar el conocimiento de ciencias de la computación	873	34,11489
Concebir, diseñar, desarrollar y operar soluciones informáticas	561	21,92
Aplicar estándares de calidad	377	14,73
Identificar oportunidades para mejorar el desempeño de las organizaciones	209	8,17
Aplicar el enfoque sistémico en el análisis y resolución de problemas	201	7,85
Desempeñar diferentes roles en proyectos informáticos, en contextos multidisciplinarios y multiculturales, tanto locales como globalizados	163	6,37
Asimilar los cambios tecnológicos y sociales emergentes	92	3,60
Comprender y aplicar los conceptos éticos, legales, económicos y financieros	83	3,24
TOTAL COMPETENCIAS DISCIPLINARIAS	2 559	100
COMPETENCIAS GENERICAS		
Capacidad de trabajo en equipo	526	20,96
Capacidad para formular y gestionar proyectos	495	19,72
Capacidad para identificar, plantear y resolver problemas	365	14,54
Capacidad de aplicar los conocimientos en la práctica	309	12,31
Capacidad de abstracción, análisis y síntesis	278	11,08
Capacidad para organizar y planificar el tiempo	254	10,12
Capacidad de aprender y actualizarse permanentemente	182	7,25
Habilidad para trabajar en forma autónoma	68	2,71
Capacidad de investigación	33	1,31
TOTAL COMPETENCIAS GENERICAS	2 510	100,00

Cuando se preguntó sobre cuáles consideran que son las razones de esta priorización, los hombres mencionan que las mujeres son más ordenadas, responsables y preocupadas del futuro, son más "estresadas" y visualizan el futuro y no solo el momento. Incluso consideran que en muchos casos cuando hay una mujer tiende a tomar el liderazgo del grupo.

Tabla 4 Total de referencias por categoría por sexo

Competencias	Hombres		Mujeres	
	Cantidad	%	Cantidad	%
Disciplinarias	2,559	50,48	792	47,24
Genéricas	2,510	49,52	784	52,75
Total	5,069			

Ambos, mujeres y hombres, indicaron que los hombres son más despreocupados por otras cosas y que tienen más sentido de logro del desarrollo de código y utilización de herramientas tecnológicas. Las mujeres mencionaron que los hombres seleccionan ciencias de la computación pues “solo piensan el terminar en trabajo y no se estresan de otras cosas”.

Igualmente hombres y mujeres consideran que se logró la formación de competencias, tanto disciplinarias como genéricas y su principal recomendación fue, dar importancia a la competencia genérica de “Trabajo en equipo” y disciplinaria “Aplicar estándares de Calidad”, aun cuando en el momento en que fueron estudiantes no creían en esta competencia, la experiencia, obtenida hasta la fecha les demuestra que realmente la calidad del software debe estar en un lugar prioritario.

9 Conclusiones y trabajos futuros

Considerando que las exigencias locales y globales obligan a un equilibrio entre habilidades disciplinarias y genéricas, las mujeres podrían estar en ventaja si toman como más importante el trabajo en equipo sobre competencias técnicas, incluso podrían ser más efectivas para ocupar puestos de liderazgo. Por otro lado los hombres con su orientación a las competencias relacionadas con las ciencias de la computación tendrían la ventaja de desarrollar productos de software de manera más efectiva cuando se trata solo de generar el código. De lo anterior se desprende que una combinación de hombres y mujeres en los equipos de trabajo produciría un balance de competencias con posibles mejores resultados.

Como es de esperar culturalmente las mujeres tienen una tendencia a valorar más competencias genéricas que los varones; sin embargo los resultados, independientemente del sexo, muestran una tendencia al balance entre competencias genéricas y disciplinarias al trabajar con PBL.

La visualización de PBL como una metodología donde las mujeres se sientan cómodas, considerando trabajo en equipo por ejemplo, podría ser un elemento para promover el incremento del ingreso y permanencia de mujeres en carreras de ingeniería.

Se muestra evidencia que el PBL y la gestión por competencias, facilita la visibilidad de competencia que tradicionalmente estudiantes de ingeniería de Sistemas no considerarían, especialmente los hombres, que a pesar de ubicar en primer lugar algunas competencias disciplinarias, colocan otras genéricas en segundo lugar. Este aspecto, que parece alejado de los estereotipos, también podría ser otro factor atrayente para que las mujeres se motiven a ingresar a carreras de Ingeniería de Sistemas.

Muchos retos se presentan luego de este estudio como son estudios longitudinales para identificar el proceso de evolución de las habilidades disciplinarias y genéricas a lo largo del proceso del desarrollo, conocer más sobre las causas de la poca participación de las mujeres o la forma de adaptación al PBL por parte de hombres y mujeres.

Finalmente este estudio no solo señala las diferencias, sino los elementos comunes en el proceso de enseñanza aprendizaje de las ingenierías. Los estudiantes tanto hombres como mujeres utilizando el PBL y una orientación por competencias, evidencian la importancia de un balance entre habilidades técnicas y genéricas, situación que garantiza una inserción laboral y social para los futuros profesionales, independiente de su género.

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PBL and society: University-industry collaborative learning

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Abstract

The requirements related to training of former grade students have recently emphasized, since the beginning of their professional practice, not only in development of theoretical knowledge but also in practical matters related of the discipline. Although the continuous university-industry cooperation is not new, constant feedback is now necessary in order to handled the changes in the training process in a correct, timely and beneficial way for everybody. This study explores and analyzes the experience of more than 10 years in the development of software applications made by students of systems engineering courses, in a continuous process of a year and a half, in a real organizations (public and private institutions as well as small and medium, called SMEs). The research focused on the perception of the representatives of the companies participating in this process in relation to the competences of the students as well as the process of exchange of knowledge and technologies. The study used a survey, which was divided in four parts: - characterization of the company and of the person in charge of answer the survey, - the real situation of the Information Technology (IT) department – the perception of students' skills and the general elements of the software project and, lastly, other aspects related to the software project and the students. The results show that a third of the projects have been carried out in organizations that repeat the experience. In addition, there is a great expectation by the companies on the software project that the students develop, not only because the software resulting of the students' project is free, but also because the companies also hope to collect new knowledge about methods of software development, technology used and IT project management, among others topics. Project oriented problem based learning (POPBL) or problem based learning (PBL), in a context where the learning environment goes beyond theory and classroom experiences, and where a university-industry relationship exist, allow to obtain benefits for both the teaching process and the companies. This is something that facilitates the continuous training process of the teacher and the contribution of the university to society.

Keywords: Project oriented problem based learning, problem based learning, POPBL, PBL, industry-university collaboration, perception of students' impact on industry.

PBL y sociedad: Aprendizaje colaborativo universidad-industria

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Resumen

Las exigencias mundiales con relación a la formación de recién graduados han enfatizado en los últimos años no solo en el desarrollo de conocimiento teóricos sino prácticos de la disciplina desde los inicios de su inserción laboral. Si bien no es nueva la continua cooperación universidad-industria, actualmente es necesaria una retroalimentación constante de manera que los cambios requeridos en el proceso de formación sean adecuados, oportunos y beneficiosos tanto para las partes como para la sociedad en general. El presente estudio explora y analiza la experiencia de más de 10 años en el desarrollo de aplicaciones realizadas por estudiantes de cursos de ingeniería de sistemas en un proceso continuo de año y medio en una organización real (instituciones públicas, privadas, así como empresas pequeñas y medianas, denominadas PYMES). La investigación profundizó en la percepción de los representantes de las empresas participantes en este proceso con relación a las competencias de los estudiantes así como del proceso de intercambio de conocimientos y tecnologías. Se aplicó una encuesta que se dividió en cuatro partes: - caracterización de la empresa y del funcionario participante, - situación de las Tecnologías de Información (TI) del departamento, - percepción de las habilidades de los estudiantes y elementos generales del proyecto, - y, finalmente, otros aspectos generales del proyecto y los estudiantes. Los resultados muestran que una tercera parte de los proyectos se ha llevado a cabo en organizaciones que repiten la experiencia. Adicionalmente, existe una gran expectativa por parte de las empresas sobre el proyecto que desarrollan los estudiantes, no solo en cuanto al producto que van a obtener de forma gratuita, si no que esperan que se compartan conocimientos sobre métodos de desarrollo de software, uso de tecnologías y gestión de proyectos de Tecnologías de Información (TI), entre otros. El aprendizaje basado en problemas basado en proyectos (POPBL por sus siglas en inglés) o el aprendizaje basado en problemas (PBL por sus siglas en inglés), en un contexto donde el ambiente de aprendizaje que va más allá de la teoría y del aula, y donde se formaliza una relación universidad-industria, permite obtener beneficios tanto para el proceso de enseñanza así como para las empresas.

Keywords: Aprendizaje basado en proyectos, aprendizaje basado en problemas, PBL, colaboración industria-universidad, percepción del impacto de los estudiantes en la industria.

1 Introducción

En el contexto actual, las universidades buscan acercarse a la industria con el fin de alinear su desarrollo con las expectativas y necesidades propias de la industria que en la mayoría de los casos recibirá al recurso humano que se forma en la misma universidad.

Al aplicar modelos pedagógicos avanzados tales como el Aprendizaje Basado en Problemas, (PBL, por sus siglas en inglés, Problem Based Learning) donde el ambiente de aprendizaje va más allá de la teoría y del aula, unido a la formalización de una relación universidad-industria, se obtienen beneficios en el proceso de enseñanza aprendizaje y beneficios concretos en las empresas como una contribución de la universidad a la sociedad.

La Universidad Nacional de Costa Rica en la carrera Ingeniería en Sistemas de información con grado de bachillerato imparte tres cursos de Ingeniería, en los cuales los estudiantes realizan un proyecto de desarrollo de software en una empresa.

Este artículo reporta los resultados de una encuesta realizada a 19 representantes de las empresas que han participado en una implementación de PBL en los cursos de Ingeniería de Sistemas. El objetivo del estudio fue explorar la perspectiva de las empresas sobre el efecto del modelo PBL en las habilidades, fortalezas y debilidades de los estudiantes, así como las ventajas y desventajas de la participación de su empresa en dicho modelo.

En el apartado 2 se presentan los fundamentos teóricos de la relación de la Industria y Universidad, luego en apartado 3 se describe el enfoque metodológico, en el cual se delimita el problema de investigación, los instrumentos y los participantes. Posteriormente, en el apartado 4 se realiza el análisis y discusión de los resultados donde se incluye además el impacto en las empresas según la perspectiva de sus representantes.

Finalmente se presentan las conclusiones que reflejan la reincidencia de las empresas al realizar varios proyectos bajo esta modalidad con PBL, las habilidades que muestran los estudiantes ante las empresas y los aportes a la industria que ellos perciben.

2 Relación de Industria Universidad

Proyectos donde participan las universidades y la industria están ampliamente documentados. Específicamente en el área de las tecnologías de información. Esta relación es compleja ya que las partes buscan objetivos diferentes y se requiere armonizar muchos componentes para lograr beneficios mutuos (Abello, 2007).

A pesar de los elementos que deben de conjugarse, la apertura de las industrias va más allá del apoyo a las universidades, los gerentes muestran apertura a esta relación, considerando el reclutamiento de nuevos talentos así como el intercambio de conocimientos (Moilanen, 2015).

La relación industria-universidad permite mayor conocimiento del mercado laboral y los requerimientos de formación, ya que los empleadores son diversos así como sus necesidades (Lashley, 2011). Aunque con un crecimiento acelerado, la ingeniería de sistemas es un área del conocimiento relativamente nueva, por un lado, la innovación debe ser alentada (Huang, 2017) (Otegui, 2006) pero por otro lado, debe generar utilidades en el menor plazo posible. Como menciona Bodas (2013), este equilibrio se debe buscar a través de un análisis desde diferentes perspectivas de la relación universidad industria.

La transferencia de tecnología es diferente para las organizaciones y los países, pero se ha demostrado sus beneficios para las partes (Gómez, 2013). Desde la perspectiva del proceso enseñanza aprendizaje, las metodologías como el PBL facilitan el desarrollo de habilidades y el trabajo de los estudiantes en organizaciones reales potencia este desarrollo (Aizpun, 2015).

El desarrollo de estas habilidades resulta inherente al contexto de la aplicación del modelo PBL en contextos reales como lo es la industria algo que ha sido reportado ampliamente (Kjærsdam, 1994) (Mills, 2003) (Moesby, 2005). Particularmente útil para las organizaciones es el desarrollo de la experiencia en los estudiantes algo que motiva a la industria a explorar y consolidar la relación con la academia (Cruz, 2016).

Otro elemento importante de la relación industria universidad es el reciente debate del papel de la academia en el contexto de las demandas y fuerzas del mercado en la sociedad en general. Esta mayor atención de la academia hacia este contexto, unido a la creciente demanda por una proactiva rendición de cuentas al público y al Estado ha generado un vínculo más estrecho entre la educación superior y la industria. Consecuentemente, se han generado cambios en los planes de estudio en donde se potencia el desarrollo de las cualidades personales para la vida y el trabajo de formación por medio de ejemplos reales (Savin-Baden, 2000).

3 Enfoque metodológico

La pregunta de investigación fue ¿cuál es el impacto generado por los proyectos desarrollados en organizaciones reales en la cátedra de ingeniería de sistemas desde la perspectiva de los representantes de las empresas?

Los estudiantes realizan un proyecto que consiste en el desarrollo de una aplicación en una organización real, durante 3 semestres en los cursos de Ingeniería de Sistemas I, II y III respectivamente. Ellos son los responsables de ubicar a las empresas, planear las reuniones, negociar el alcance y los requerimientos, definir la arquitectura, planificar las pruebas, desarrollar los productos de software. El rol del profesor es de facilitador y su relación con la empresa es prácticamente nula.

Para conocer las perspectiva de las organizaciones sobre el impacto de los proyectos desarrollados, se aplicó una encuesta en línea que se dividió en cuatro partes: - caracterización de la empresa y de la persona que completó la encuesta, - situación de las Tecnologías de Información (TI) del departamento - percepción de las habilidades de los estudiantes y elementos generales del proyecto y la última relacionada con las ventajas, desventajas de la participación en el proyecto y la percepción de fortalezas y debilidades de los estudiantes.

Basados en el programa del curso, plan de estudios (Escuela de Informatica, 2004) y la utilización de PBL (Kjærsdam, 1994), se estableció la siguiente división de competencias y habilidades adquiridas por los estudiantes: a) técnicas (relacionadas con ingeniería de sistemas), b) administración de proyectos y c) habilidades blandas ("comunicación eficaz, trabajo en equipo, flexibilidad, ética profesional, pensamiento creativo, habilidades de liderazgo y paciencia)" (Nichols, (2003))

La encuesta comprendió 38 preguntas en total, de las cuales 22 fueron cerradas, 2 semiabiertas y 14 abiertas. Estas últimas se utilizaron para reforzar las conclusiones resultantes del análisis de las preguntas cerradas, según las variables definidas.

3.1 Población de empresas participantes.

3.2 En la Selección de la muestra

Inicialmente se seleccionaron las empresas donde se contaba con información de contacto (80), luego se trató de ubicar telefónicamente a funcionarios que participaron en el desarrollo del proyecto, resultando 45 empresas de las cuales se seleccionó aleatoriamente un 50%, distribuidas de acuerdo con el porcentaje que representaban por categoría según tamaño en la población de empresas con información de contacto: micro, pequeña, mediana y grande, para un total de 24 personas a ubicar.

Tabla 5 Población de Empresas participantes por clasificación MIDEPLAN (Ministerio de Planificación de Costa Rica), se muestra la información de las empresas que conforman la población de estudio.

3.3 Selección de la muestra

Inicialmente se seleccionaron las empresas donde se contaba con información de contacto (80), luego se trató de ubicar telefónicamente a funcionarios que participaron en el desarrollo del proyecto, resultando 45 empresas de las cuales se seleccionó aleatoriamente un 50%, distribuidas de acuerdo con el porcentaje que representaban por categoría según tamaño en la población de empresas con información de contacto: micro, pequeña, mediana y grande, para un total de 24 personas a ubicar.

Tabla 5 Población de Empresas participantes por clasificación MIDEPLAN(Ministerio de Planificación)

Clasificación	Cantidad	Porcentaje
Microempresa	9	8%
Mediana	29	25%
Pequeña	32	27%
Grande	47	40%
Total	117	100%

En la

Tabla 6 Distribución de empresas seleccionadas y finalmente fue posible contactar a 19 de ellos que representan la muestra estudiada.

Tabla 6 Distribución de empresas seleccionadas

Tipo empresa	Empresas con información de contacto	Empresas ubicadas	Muestra (50%)
Grande	41	26	13
Mediana	16	8	4
Pequeña	19	14	7
Micro	4	0	0
Total	80	48	24

4 Análisis de resultados y discusión

El 73% de las empresas son públicas y en su mayoría (85%) poseen algún tipo de soporte para las TI, en un 78% se utilizaba al menos un sistema de información, aunque no estuviese relacionado con el proyecto a desarrollar. Más de la mitad de las empresas ha tenido contacto con las TI y la mayoría de los participantes (68%) tenían más de 5 años de experiencia en la participación de proyectos de desarrollo de software, se deduce que poseían algún conocimiento relacionado con la participación en este tipo de proyectos, sin embargo la mayoría de los departamentos (79%) procesaban más del 50% de su información de manera manual. También un porcentaje tan alto en procesos manuales podría indicar que el departamento no ha logrado una madurez en TI (ver Tabla 7. Cantidad de empresas según porcentaje de información procesada manualmente en la oficina o departamento)

Tabla 7. Cantidad de empresas según porcentaje de información procesada manualmente en la oficina o departamento

Información procesada manualmente	Cantidad de empresas	Porcentaje
de 0 a 50%	4	21
de 50 a 80%	5	26
de 90 a 100%	10	53
Total	19	100

Con respecto a la pregunta cuál es su percepción sobre una habilidad específica, la escala de posibles respuestas se definió como: totalmente de acuerdo, de acuerdo, en desacuerdo y totalmente en desacuerdo. La habilidad con mayor porcentaje es la que indica que el estudiante posee suficiente formación en aspectos éticos con 94% en totalmente de acuerdo y de acuerdo la más baja es suficiente formación en Administración de proyectos con un 63%.

Con respecto a las habilidades técnicas, modelar procesos de negocio es la más baja con un 68% (en totalmente de acuerdo y de acuerdo). En esta categoría el porcentaje más alto lo tiene el levantamiento de requerimientos, con un 89,5%, siendo congruente con el grado de importancia que se le da al tema en los cursos, igualmente, con 84%, las destrezas relacionadas con adecuada documentación análisis y diseño de sistemas, muestran el énfasis que se da en los cursos a estas áreas.

Retomando los resultados del estudio, los porcentajes de las habilidades con menor porcentaje promedio en desacuerdo y muy en desacuerdo son las relacionadas a la administración de proyectos, con un 64%, porcentaje que requiere de atención, considerando que el de aprendizaje basado en problemas orientado a proyectos, es la filosofía de aprendizaje que se utiliza en la Cátedra de Ingeniería de Sistemas.

4.1 Impacto en las empresas desde su perspectiva.

Se pretende también conocer el impacto en el proceso de transferencia de conocimiento y el beneficio obtenido por la organización, desde la perspectiva de las empresas, así como proponer ajustes para mejorar el desarrollo del proyecto en función del proceso de aprendizaje, el plan de estudios y los programas de los cursos de Ingeniería de acuerdo con los resultados obtenidos.

Al conocer cuáles conocimientos o habilidades considera que adquirió usted o algún funcionario como parte de la experiencia en este proyecto de desarrollo, la mayoría (42%) los relaciona con aspectos a metodología y gestión de proyectos. En los cursos de Ingeniería de Sistemas I, II y III, los estudiantes están constantemente en contacto con varias herramientas y técnicas de Administración de los proyectos, para lograr un adecuado seguimiento y ejecución de los planes establecidos para el éxito de los proyectos.

Los conocimientos y habilidades tecnológicas (hardware y software) muestran un 26%. Dentro de la categoría de otros conocimientos están el conocimiento de la aplicación, de la relación con estudiantes y aprender a analizar los procesos de la organización que muestran un 16%. El total de personas que realizaron la encuesta que adquirieron algún conocimiento o habilidad es de 84%, evidenciando que existe intercambio entre los participantes en beneficio mutuo.

También con 16% se observa que los participantes indican que no perciben ningún conocimiento adquirido de la experiencia, porcentaje que debe ser analizado ya que uno de los objetivos del trabajo con los estudiantes es lograr un aprendizaje para todos los participantes y que el proyecto no se limite a una actividad pedagógica o requisito para aprobar un curso.

Tabla 8 Conocimientos o habilidades que considera adquirió usted o algún funcionarios como parte de la experiencia en este proyecto de desarrollo

Conocimiento o habilidad	Cantidad	Porcentaje (%)
Tecnológicas relacionadas con el hardware y software	5	26
Metodología, forma de trabajo y gestión de proyectos de desarrollo de software	8	42
Otras	3	16
Ninguna	3	16
Total	19	100

5 Conclusión

Los resultados muestran que una tercera parte de los proyectos se ha llevado a cabo en organizaciones que repiten la experiencia y que existe una gran expectativa por parte de las empresas sobre el proyecto que desarrollan los estudiantes, no solo en cuanto al producto que van a obtener de forma gratuita, si no que esperan que se compartan conocimientos sobre métodos de desarrollo de software, uso de tecnologías y gestión de proyectos de TI, entre otros.

Lo anterior pone en evidencia que los estudiantes realizan actividades y aplican conocimientos, técnicas y herramientas relacionadas con la Administración de Proyectos que transmiten a las empresas, pero la mayoría de los participantes consideran que las habilidades de los estudiantes relacionadas con esta área son insuficientes; situación que amerita un mayor análisis sobre cuáles son las expectativas de las empresas con respecto a este tema y con ello, fortalecer los contenidos y las destrezas de los estudiantes.

El empoderamiento y trabajo independiente de los equipos con las empresas, los lleva a tomar un liderazgo técnico muy útil para las empresas y para el desarrollo de habilidades en los estudiantes.

Al aplicar PBL donde el ambiente de aprendizaje va más allá de la teoría y del aula, unido a la formalización de una relación universidad-industria se muestra que la experiencia ha beneficiado no solo al proceso de enseñanza aprendizaje, sino que ha dado beneficios concretos a las empresas, facilitando la formación de los académicos y brindando un aporte de la universidad a la sociedad. La retroalimentación permanente de la industria con la academia es fundamental para el proceso de mejoramiento continuo de ambas partes.

En el desarrollo con empresas reales, los estudiantes son evaluados por profesionales con experiencia y un nivel de exigencia alto, ellos evalúan a los estudiantes como profesionales. No obstante, la percepción de los representantes de las empresas sobre las habilidades y destrezas del estudiante, como resultado del trabajo conjunto empresa-universidad en el desarrollo de un proyecto, es una percepción con resultados satisfactorios en habilidades específicas y técnicas, cuyos porcentajes motivan a explorar en futuros estudios con el fin de mejorar la percepción de representantes de las empresas.

Futuras investigaciones podrían explorar más a fondo la percepción según los tipos de industria, y realizar análisis más detallados sobre las oportunidades de mejora para la academia desde la perspectiva de los requerimientos de la industria.

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Adaptation of the Curriculum to the Entrepreneurial Intention: A Study through the Analysis of the Performance-Importance Map (IPMA)

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Abstract

Offering a course in line with the social reality of students is a challenge for universities. In a scenario of crisis, exponential increase in technology and lack of job offers, entrepreneurship emerges as a viable option to ensure a sustainable model of professional that contributes to society and generates jobs. However, curricula are not always designed for this purpose. Thus, the objective of this article is to investigate to what degree the curricular matrix of the Faculty of Technology of the University San Francisco Xavier de Chuquisaca (USFX) is adequate to the entrepreneurial intention. To reach this objective, an exploratory research was carried out through the structural equations to a sample of 295 Engineering students. The sample was probabilistic with statistical power of 80%. The model of TPB (Theory of Planned Behaviour) of Ajzen was adopted. The results allow to affirm that the students have an entrepreneurial attitude in 80.3%. However, the teaching model only reaches 3% of its subjects with business contents. An adaptation of the curriculum incorporating business subjects and activities that develop in students their entrepreneurial capacities enhancing their entrepreneurial intention, will allow to train professionals with a high entrepreneurial attitude able to create a new company. It will be enriching for the science to extend this research to samples of students of other specialties and universities, since this research had limitations when selecting only students of the area of technological sciences of the USFX.

Keywords: Curriculum, Entrepreneurial Intent, Behaviour, Structural Equations.

Adecuación del Currículo a la Intención Emprendedora: Un Estudio por medio del análisis del mapa de Rendimiento-Importancia (IPMA)

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Resumen

Ofrecer un curso en consonancia con la realidad social de los alumnos es un desafío para las Universidades. En un escenario de crisis, aumento exponencial de la tecnología y falta de ofertas de empleo, el emprendimiento surge como una posible opción para garantizar un modelo sostenible de profesional que contribuye con la sociedad y genera empleos. Sin embargo, no siempre los currículos están diseñados para tal finalidad. Así, el objetivo de este artículo es investigar en qué grado la matriz curricular de la Facultad de Tecnología de la Universidad San Francisco Xavier de Chuquisaca (USFX) está adecuada a la intención emprendedora. Para alcanzar este objetivo fue adoptado el modelo de TPB (Teoría del Comportamiento Planeado) de Ajzen, realizando una investigación exploratoria por medio de las ecuaciones estructurales a una muestra de 295 estudiantes de Ingeniería, la muestra fue probabilística con poder estadístico de 80%. Los resultados permiten afirmar que los estudiantes tienen una actitud emprendedora en un 80.3 %. Sin embargo, el modelo de enseñanza solo alcanza al 3 % de sus asignaturas con contenidos empresariales. Una adecuación del currículo incorporando asignaturas empresariales y actividades que desarrollen en los estudiantes sus capacidades empresariales potenciando su intención emprendedora, permitirá formar profesionales con una elevada actitud emprendedora capaces de crear una nueva empresa. Será enriquecedor para la ciencia ampliar estas investigaciones a muestras de estudiantes de otras especialidades y universidades, dado que esta investigación tuvo limitaciones al seleccionar solo estudiantes del área de ciencias tecnológicas de la USFX.

Palabras-Clave: Currículo, Intención emprendedora, Comportamiento, Ecuaciones Estructurales.

1 Introducción

Se ha discutido bastante respecto del futuro de los empleos en los países. Estas indagaciones se potencializan en países insertados en un contexto donde prevalece altas tasas de desempleo, como Latino América (Pizarro, 2001). El efecto de esta falta de empleos ofrecidos formalmente por empresas conlleva a que los ciudadanos emprendan sus propios negocios. El estudio realizado por Global Entrepreneurship Monitor- GEM en América Latina, ubicó a Bolivia entre los tres países con más actividad emprendedora, por detrás de Ecuador y Perú (Querejazu, Zavaleta, & Mendizabal 2014)

Aunque diversos factores pueden influir en el comportamiento emprendedor (Bohnenberger & Freitas, 2007), se sabe que la formación del estudiante universitario direccionada a la actitud emprendedora puede promover experiencias más provechosas para el individuo. Así, conocer los currículos de las universidades y comprender su adherencia a la actitud emprendedora se hace necesario para comprender más a cerca de la enseñanza de estos valores en la formación estudiantil.

El problema de este estudio es: comprender los factores que deben ser potencializados para mejorar la intención emprendedora en la Facultad de Tecnología de la Universidad San Francisco Xavier de Chuquisaca-USFX.

Este tema se justifica socialmente por la importancia del empresario local para las ciudades bolivianas, especialmente en Sucre, donde está situada la USFX. Comprender estos factores que ratifican la actitud emprendedora puede generar un apoyo para la economía, así como para la generación de empleo.

De este modo, el objetivo de este estudio es investigar en qué grado la matriz curricular de la Facultad de Tecnología de la Universidad San Francisco Xavier de Chuquisaca (USFX) está adecuada a la intención emprendedora.

Para alcanzar este objetivo será realizada una investigación por medio de las ecuaciones estructurales, utilizando la técnica de IPMA (*Importance-Performance Map Analysis*).

2 Fundamentación teórica

2.1 Intención emprendedora

Koe *et al.*, (2012 p.198) junto a otros investigadores indican que los emprendedores no nacen sino se hacen, por lo que pueden ser entrenados. De esta manera los emprendedores se moldearán a partir de cualidades innatas fortalecidas con un entrenamiento. Sin embargo, para dar este paso deberán están convencidos de ser emprendedores lo que hace que sea planificado. De la misma manera Krueger et al., (2000) manifiesta que las actividades del emprendimiento son intencionales, que comienzan con cierto grado de intención empresarial antes de ser un emprendedor.

En síntesis, el emprendimiento o espíritu emprendedor comprende los actos de creación, renovación o innovación organizacional, que ocurren dentro o fuera de una organización (Sharma & Chrisman, 1999) y es una forma de pensar resaltando las oportunidades frente a las amenazas. Para Krueger *et al.*, (2000) es un tipo de comportamiento planificado, siendo los modelos de Shapero (1982), de las intenciones empresariales y de Ajzen 1991 de la conducta planificadas, herramientas valiosas para comprender y predecir los procesos empresariales.

2.2 Modelo del Comportamiento Planeado -TPB

Desde el punto de vista de la decisión de convertirse en emprendedor puede comprenderse algo voluntario y consciente (Krueger *et al.*, 2000), lo que hace un comportamiento planeado.

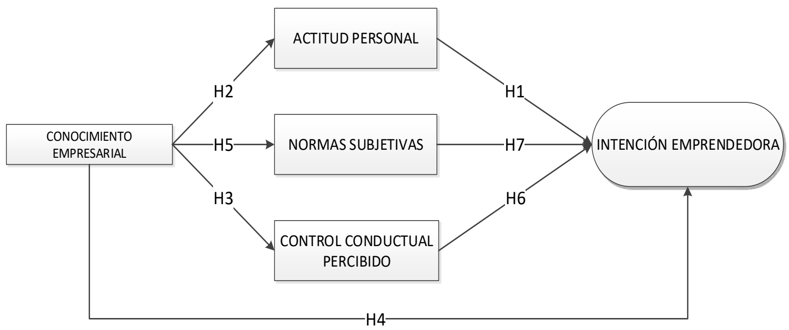

Figura 1 - Modelo de la Intención Emprendedora (MIE).

En este sentido, Ajzen, (1991) desarrollo su teoría de comportamiento planificado (TPB), donde la intención de realizar comportamientos de diferentes clases puede predecirse con la actitud hacia el comportamiento, las normas subjetivas y el control del comportamiento percibido, siendo un modelo importante del proceso cognitivo para la evaluación de intención empresarial que es el resultado de un comportamiento intencional y planificado (Krueger *et al.*, 2000), por lo que el uso de TPB para investigar la intención empresarial es viable. Por otra parte, Koe *et al.*, (2012) manifiesta que es importante integrar al modelo TPB otras variables relevantes para incrementar la capacidad de explicar y predecir la intención. Adicionalmente Delgado Piña et al., (2008) manifiesta que el deseo de crear un negocio está relacionado con la posibilidad de crear un negocio, otros factores sociales, la auto eficiencia y la edad.

Por su parte, Liñán, Rodríguez-Cohard, & Rueda-Cantuche, (2011) consideran que el conocimiento personal de los emprendedores influye significativamente en la decisión de creación de empresas. Liñán, (2004) nos ofrece un modelo fruto de integrar los modelos de Shapero 1982 de las intenciones empresariales y de Ajzen 1991 de la conducta planificada. Los autores proponen el Modelo de Intención Emprendedora (MIE) mostrado en la figura 1 que corresponde a una adecuación del modelo de (Liñán, 2004 ; Wu & Wu, 2008).

Los conocimientos que adquieren los estudiantes a través de su formación en su carrera profesional adicionales a los conocimientos sobre emprendimiento, cursos empresariales y otras habilidades empresariales especiales mejora las intenciones empresariales de los individuos (Koe *et al.*, 2012). Por su parte, Devonish, Philmore, Charles-Soverall, Young, & Pounder, (2010) mencionan que los empresarios pueden aplicar sus conocimientos para influir en sus propios hijos y puedan desarrollar sus negocios familiares o para desarrollar nuevos negocios.

Pero no solo el conocimiento de un individuo es determinante para una iniciativa emprendedora, si no también son importantes la percepción que tenga de los conocimientos y habilidades que posea (Delgado Piña *et al.,* 2008). La auto-eficiencia para identificar oportunidades de negocio, mercados, fuentes potenciales de financiamiento son considerados factores cognitivos que afectan a la intensión emprendedora (Baughn *et al.*, 2006) y en la magnitud que una persona considere que posea ciertas destrezas, podrá considerar poner en práctica alguna iniciativa (Krueger *et al.*, 2000). De este modo la intención emprendedora de un estudiante universitario estará directamente influenciada por el contenido curricular de su carrera, si este contiene asignaturas que fortalezcan el conocimiento empresarial.

2.3 El Currículo de la USFX

La estructura curricular de la facultad de tecnología que cuenta con 11 carreras a nivel licenciatura y 4 carreras a nivel Técnico Superior se divide en cuatro áreas de formación: Ciencias con asignaturas de matemáticas, física, química y biología. Ingeniería, Formación profesional y Formación complementaria con temas integrales y técnico complementarias con actividades teóricas, prácticas y experimentales. También identificamos 10 asignaturas de formación empresarial de 361 asignaturas que se imparten en la en la facultad de Tecnología. En la figura 2 se muestra la distribución de asignaturas, elaborado en base al plan de estudios de la Facultad de tecnología

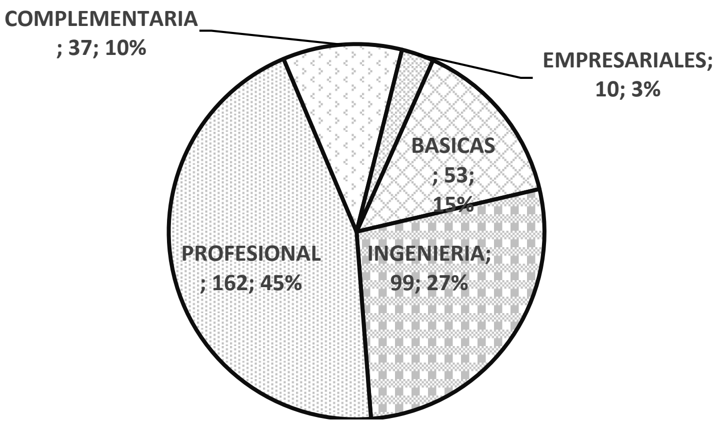

Figura 2: Distribución curricular por áreas de formación

Se puede percibir, que en las áreas de formación (Figura 2), solo el 3 % corresponden a asignaturas empresariales que se imparten en la carrera de Ingeniería Industrial, Ingeniería Química, Ingeniería de Alimento, Ingeniería de Sistemas e ingeniería Mecánica, siendo una participación muy escasa de las asignaturas empresariales.

3 Métodos

Este estudio es del tipo exploratorio con enfoque cuantitativo. La técnica elegida fue la de ecuaciones estructurales porque puede aplicarse con modelos complejos e identificar factores más importantes (Hair, *et* *al*., 2016). La investigación se realizó en la Ciudad de Sucre - Chuquisaca con una población proyectada para el año 2017 de 621.14 miles de habitantes, según el Instituto Nacional de Estadística, está localizada entre los meridianos 57º 26´ y 69º 38´ de longitud occidental del meridiano de Greenwich y los paralelos 9º 38´ y 22º 53´ de latitud sur. El objeto de investigación fueron los estudiantes de la Facultad de Tecnología de la Universidad San Francisco Xavier de Chuquisaca. La universidad posee 50.05 miles de estudiantes universitarios. La Facultad de Tecnología tiene matriculados hasta la gestión 1/2015, 8485 estudiantes distribuidos en las diferentes carreras, cuenta con 176 docentes y 56 administrativos.

El instrumento para la recolección de datos fue el modelo adaptado mostrado la figura 1, que consta de 5 variables y 24 preguntas. La encuesta fue rellanada de manera física durante el mes de abril de 2017. La muestra para PLS-SEM es no-paramétrica y se basa en propiedades de regresión de mínimos cuadrados parciales (Hair, *et al.* , 2016). La muestra fue calculada con el *software G*Power.* El efecto fue mediano (0,15), ideal para estudios exploratorios, la significancia fue de 5% y el nivel del poder estadístico fue de 0,8. Como el modelo posee 4 variables independientes, la muestra mínima es de 77 individuos. Fueron realizadas 295 encuestas, siendo esta el valor n del estudio (n=295).

Los resultados fueron calculados con el programa *Smart Partial Least Square* (*SmartPLS*). El análisis cuenta de tres pasos: diseñar el modelo basado en la literatura, realizar los tests de Validez y confiabilidad del modelo y la valoración del modelo. Adicionalmente fue realizado un test de IPMA - *Importance-Performance Map Analysis*, para conocer cuáles son las prioridades para mejorar en el currículo. Todos los tests de Validez y Confiabilidad fueron satisfactorios (α=0,95; Rho_A=0,96 y *Fc*=0,96).

4 Resultados y Análisis

Después de los análisis de fiabilidad e validad el modelo de actitud emprendedora fue calculado conforme figura 3.

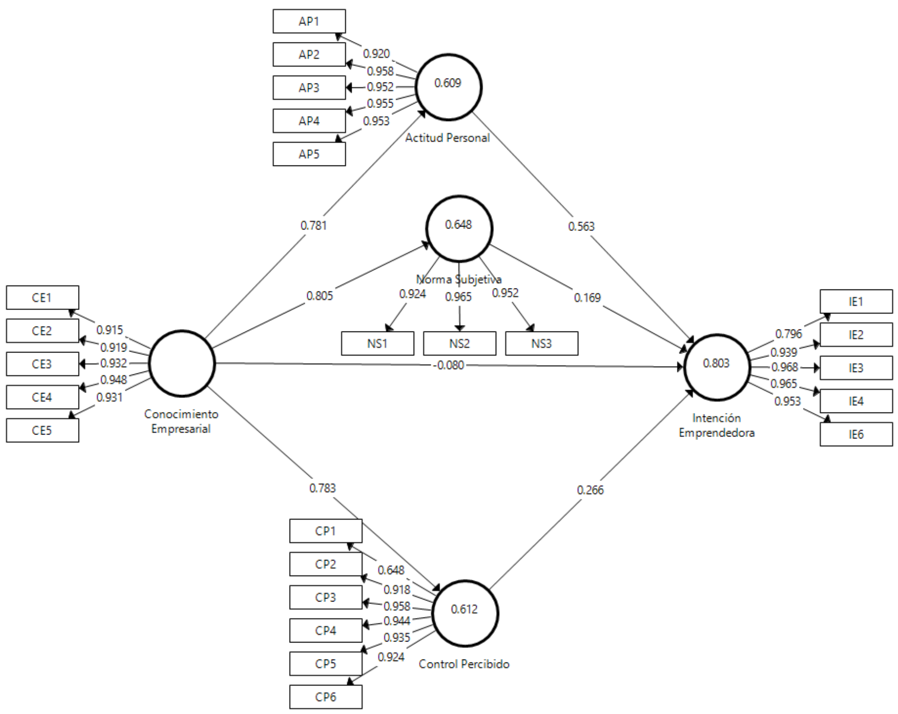

Figura 3. Modelo de Ecuaciones Estructurales
Fuente: Elaborado por los autores con base en los resultados del *SmartPLS*

Según Ramírez *et al* (2014), para valorar el modelo de medida se debe observar dos índices, el R^2 y el *Beta (patch β)*. El R^2 indica el poder de explicación del modelo. En esta ocasión se puede percibir que el conocimiento empresarial explica la norma subjetiva en 64,8%, la actitud personal en 60,9% y el control percibido en 61,2%.

Y que la intención emprendedora es explicada en 80,3%. Valores arriba de 50% son considerados reveladores (Falk & Miller, 1992). Así este modelo posee un buen poder de explicación de las variables. Así se puede percibir que los estudiantes de la Facultad de tecnología tienen una elevada intención emprendedora.

El segundo índice es el Beta y está relacionado al grado de influencia de una variable independiente sobre una variable dependiente. Para que un Beta sea considerado significante, el valor debe ser más grande o superior a 0,2, asegurando la hipótesis como verdadera (Ramirez *et al.*, 2014).

Se puede percibir que la variable que más influye en la intención emprendedora es la Actitud Personal, seguido de Control Percibido. La norma Subjetiva no fue significante para el test de Beta. Eso significa que los factores que miden la presión social de esta variable no influyen en la intención emprendedora de los estudiantes.

Para complementar el análisis de *patch β,* se utilizó *el Bootstrapping.* El propósito de este análisis es ratificar los resultados de las hipótesis con el Beta. Para eso, se utiliza un test más diseminado en la literatura para muestras no paramétricas, el *t de student. T*ambién fue calculado el *p-value* para evitar errores del tipo I y II.

Para que las hipótesis sean aceptadas, los valores de *t de student* deben ser iguales o superiores a 1,96, y los valores de *p-value*, deben ser inferiores a 0,05 (Ramirez *et al.,* 2014). Se Puede percibir, en la tabla 1, que las hipótesis H1, H2, H3, H5, H6 e H7 fueran confirmadas. La hipótesis H7 que había dado próxima a 0,2 por medio del beta, fue confirmada en el test de *t de student*. La hipótesis H4 fue negada en los dos test realizados.

Tabla 1. Test de Hipótesis

	Hipótesis	Beta (β)	*t de student*	*p-value*	Resultado
H1	Actitud Personal-> Intención Emprendedora	0.563	7.883	0.000	Aceptada
H2	Conocimiento Empresarial -> Actitud Personal	0.781	28.534	0.000	Aceptada
H3	Conocimiento Empresarial -> Control Percibido	0.783	28.122	0.000	Aceptada
H4	Conocimiento Empresarial -> Intención Emprendedora	-0.080	1.656	0.098	No Aceptada
H5	Conocimiento Empresarial -> Norma Subjetiva	0.805	33.652	0.000	Aceptada
H6	Control Percibido -> Intención Emprendedora	0.266	3.718	0.000	Aceptada
H7	Norma Subjetiva -> Intención Emprendedora	0.169	2.175	0.030	Aceptada

Fuente: Elaboración propia

Observando la tabla 1 podemos manifestar que el conocimiento empresarial tiene una alta significancia en la actitud personal y el control percibido para fortalecer la intención emprendedora de los estudiantes y comparando con la composición curricular de la Facultad de Tecnología de la Universidad USFX mostrado en la figura 2, se puede verificar que la reducida cantidad de asignaturas con enfoque en áreas empresariales es negativo para fortalecer la intención emprendedora.

Para comprender los factores que deben ser potencializados en el currículo de la USFX fue realizado el análisis de IPMA. Es muy útil para generar el análisis de rendimiento versus importancia para una aplicación práctica de los estudios (Ringle & Sarstedt, 2016).

La técnica es compuesta de dos ejes, el X y Y. El eje Y corresponde al rendimiento, identificando cuál es el rendimiento del objeto de estudio, en este caso del currículo de la USFX. Aunque las escalas de medida puedan variar de un estudio a otro, para calcular los valores del eje Y, son reordenadas en un intervalo de 0 a 100 permitiendo una comprensión más sencilla.

El eje X es la importancia, ubicando los principales atributos para un determinado problema, en este caso, la intención emprendedora. Para realizar los cálculos de importancia deben observarse los valores de Beta, sumando las relaciones (flechas), directas e indirectas que llevan hasta la variable dependiente. Fueron realizados los cálculos de IPMA para las variables del modelo y los resultados se muestran en la figura 4.

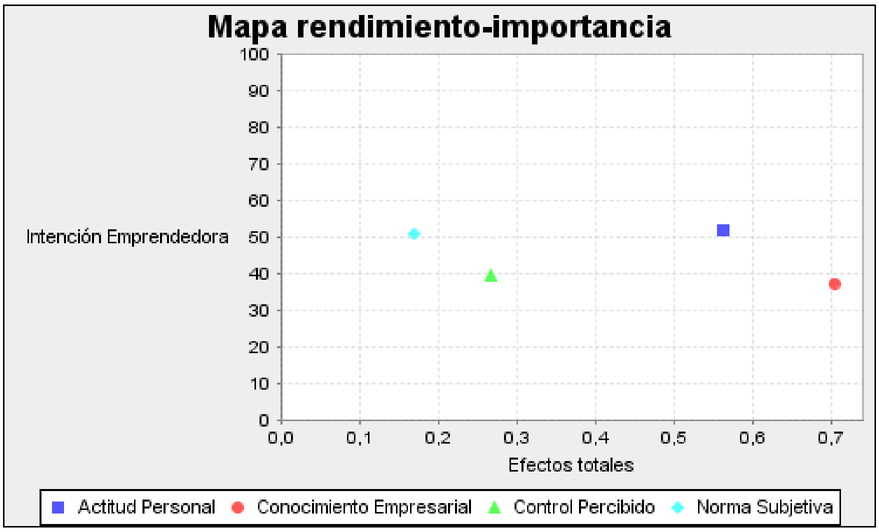

Figura 4. Matriz del IPMA de variables
Fuente: *SmartPLS*

Se puede percibir que los factores de prioridad son aquellos que se encuentran en el cuadrante inferior derecho, que revela aquellas características que son las más importantes, pero que tiene un bajo desempaño. El segundo es el cuadrante inferior izquierdo, que explican las características menos importantes y tienen un bajo rendimiento. Por último, están los cuadrantes superior derecho, que son aquellos atributos importantes y que tienen un rendimiento elevado y el cuadrante superior izquierdo, que son aquellos atributos que son menos importantes y que posee un alto rendimiento

Así se puede percibir que el conocimiento empresarial debe ser el primer valor para priorizar, pues es lo más importante con un valor de 0,703 y un rendimiento bajo de 32,007. El segundo punto a ser priorizado es el control percibido, aunque no sea un ítem tan importante, pero tampoco tenemos buen rendimiento. Después se debe priorizar la actitud personal considerando que es un reflejo de las creencias y opiniones sostenidas por un individuo sobre el comportamiento (Wu & Wu, 2008) y finalmente las normas subjetivas que no es un predictor significativo en la intención emprendedora.

La composición de asignaturas en el currículo de la facultad de tecnología nos muestra que es escasa la enseñanza para fortalecer el conocimiento empresarial. Koe *et al.*, (2012) indica que los conocimientos que adquieren los estudiantes a través de su formación en su carrera profesional adicionales a los conocimientos sobre emprendimiento, cursos empresariales y otras habilidades empresariales especiales mejoran las intenciones empresariales de los individuos Por su parte, Devonish, Philmore, Charles-Soverall, Young, & Pounder, (2010) mencionan que los empresarios pueden aplicar sus conocimientos para influir en sus propios hijos y puedan desarrollar sus negocios familiares o para desarrollar nuevos negocios. Haciéndose una necesidad el de adecuar el currículo con asignaturas y actividades extra curriculares como seminarios, que permitan ampliar el conocimiento empresarial para fortalecer la intención emprendedora de los estudiantes.

Respecto al control percibido del comportamiento definido como la percepción de una persona de su capacidad de realizar un comportamiento específico (Wu & Wu, 2008), en este caso el de desarrollar un proyecto empresarial y controlar el proceso de creación de una nueva empresa, conocimiento que no se imparte según las asignaturas del currículo de la facultad de tecnología.

Una adecuación del currículo incorporando asignaturas empresariales y actividades que desarrollen en los estudiantes sus capacidades empresariales para potenciar su intención emprendedora, permitirá formar profesionales capaces de crear una nueva empresa.

5 Conclusiones, limitaciones y futuras líneas de investigación

El problema de este estudio fue comprender que factores deben ser potencializados para mejorar la intención emprendedora de los estudiantes en la Facultad de Tecnología de la Universidad San Francisco Xavier de Chuquisaca (USFX). Los resultados permiten afirmar que estos factores son el conocimiento empresarial y el control percibido.

En base a estos resultados, podemos mencionar que la USFX debe promover el conocimiento empresarial en los estudiantes a través de cursos, conferencias, foros, intercambio de estudiante entre universidades, contacto con empresarios, introduciendo en su malla curricular este conocimiento para permitir fortalecer esa intención emprendedora.

Así el objetivo de la investigación que fue investigar en qué grado la matriz curricular de la Facultad de Tecnología de la Universidad San Francisco Xavier de Chuquisaca (USFX) está adecuada a la intención emprendedora. El conocimiento empresarial es una variable que tiene una alta influencia en la actitud personal y el control percibido y el currículo tiene solo el 3% de asignaturas orientadas al conocimiento empresarial. Estos resultados indican que la matriz curricular tenga que adecuarse para fortalecer la intensión emprendedora que los estudiantes poseen.

El presente estudio tuvo sus limitaciones en la selección de la muestra que abarca solo a estudiantes de la facultad de tecnología de la USFX.

Para una agenda futura se sugiere ampliar las investigaciones a muestras de estudiantes de otras especialidades y universidades de nuestro país incorporando una segmentación demográfica, investigaciones longitudinales en el periodo de profesionalización de los estudiantes.

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The Combined Effect of the Self-directing Learning and Cooperative Learning in the Students' Performance

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Abstract

The purpose of this study was to apply the self-directed learning using the cooperative learning to improve the problem-solving process of students who are studying the subject of thermodynamics offered in a major in electrical engineering from an Ecuadorian public University. Participated in this study 24 students who are registered in the subject of thermodynamics with age between 19 and 21 years old. The instructional task selected was the application of the first law of thermodynamics to isometric, isobaric, isothermal, and adiabatic processes. Which was presented in a self-directed learning package consists of four independent modules. This content had not been taught to students. In addition, the rules of the magic square self-instructions modules. Instruments include the pretest and posttest that were equal and contained 25 multiple-choice questions. This investigation followed the following procedure: (1) apply the pretest. (2) Form random cooperative learning groups using the technique of "cards". Each group was formed by four students (3) Apply the "Chain Gang" to the construction of the magic square. (4) Randomly deliver modules of self-directed learning to students in each group so that they study independently. (5) Share what they learned with the students in each group having the same content. (6) Return to their groups and teach what they have learned to their classmates. (7) Apply the posttest. The paired t test indicates that there was a significant difference between the posttest and the pretest ($t = 16.37$, $p < 2.2x10-16$). The results show that the combination of the self-directed learning and cooperative learning enhance students' problem-solving skills.

Keywords: Active Learning; Cooperative Learning; Self-directing Learning; Instructional Design, Achievement.

El Efecto Combinado del Aprendizaje Autodirigido y el Aprendizaje Cooperativo en el Desempeño de los Estudiantes

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Resumen

El propósito de este estudio fue aplicar el aprendizaje autodirigido utilizando el aprendizaje cooperativo para mejorar el proceso de resolución de problemas de los estudiantes de ingeniería. Participaron en este estudio 24 estudiantes que están registrados en la asignatura de termodinámica ofrecida a la carrera de ingeniería eléctrica de una universidad pública ecuatoriana, con una edad comprendida entre los 19 y 21 años. La tarea instruccional seleccionada fue la aplicación de la primera ley de la termodinámica a los procesos isométrico, isobárico, isotérmico y adiabático. La misma que estaba presentada en un paquete de aprendizaje autodirigido conformada por cuatro módulos independientes. Este contenido no había sido enseñado a los estudiantes. Además, los módulos autoinstruccionales de las reglas del cuadrado mágico. Entre los instrumentos están la prueba de entrada y de salida que eran iguales y contenían 25 preguntas de múltiple respuesta. Esta investigación siguió el siguiente procedimiento: (1) Aplicar la prueba de entrada. (2) Formar los grupos de aprendizaje cooperativo de manera aleatoria utilizando la técnica de las "cartas de naipe". Cada grupo estuvo conformado por cuatro estudiantes (3) Aplicar el "Chain Gang" a la construcción del cuadrado mágico. (4) Entregar aleatoriamente los módulos de aprendizaje autodirigido a los estudiantes de cada grupo para que lo estudien de manera autónoma. (5) Compartir lo aprendido con los estudiantes de cada grupo que tienen el mismo contenido. (6) Regresar a sus grupos y enseñar lo que han aprendido a sus compañeros. (7) Aplicar la prueba de salida. La prueba t emparejada indica que hubo una diferencia significativa entre la prueba de salida y la prueba de entrada ($t = 16{,}37$, $p < 2.2 \times 10^{-16}$). Los resultados obtenidos muestran que la combinación del aprendizaje autodirigido y el aprendizaje cooperativo mejoran las habilidades de resolución de problemas de los estudiantes.

Palabras claves: Aprendizaje Activo; Aprendizaje Cooperativo; Aprendizaje Autodirigido; Diseño Instruccional; Aprovechamiento.

1 Introducción

La Oficina de Acreditación para Ingeniería y Tecnología (ABET por sus siglas en inglés) ha establecido 11 criterios que son importantes en la formación del futuro ingeniero. Para el presente estudio se tomaron en consideración los siguientes criterios: El primero, la habilidad para funcionar efectivamente como miembro o líder de un equipo técnico y el segundo, comprender la necesidad y la habilidad para engancharse en el aprendizaje autodirigido para el desarrollo profesional continuo (ABET, 2016).

El primer criterio está relacionado con el aprendizaje cooperativo que se define como un conjunto de estudiantes trabajando en grupos pequeños y heterogéneos para resolver problemas que han sido asignados por el profesor, para maximizar su propio aprendizaje y el de los miembros de su grupo. Esta tarea, los estudiantes tienen que ejecutarla con o sin la supervisión directa del profesor, el mismo que actúa como un facilitador. (Johnson, Johnson & Holubec, 1993; Cohen, 1994; Cottell, 2010). El segundo criterio está relacionado con el aprendizaje autodirigido que se define como un sistema de instrucción en el cual los estudiantes aprenden significativamente un material previamente asignado a su propio ritmo y sin la ayuda del profesor (Long, 1990; Piskurich, 1993; Gibbons, 2002; Jacobs, Power & Inn, 2002).

En consecuencia, el propósito de este estudio fue aplicar el aprendizaje cooperativo utilizando el aprendizaje autodirigido para mejorar el proceso de resolución de problemas de los estudiantes que están cursando la asignatura de termodinámica ofrecida a la carrera de ingeniería eléctrica de una universidad pública ecuatoriana.

1.1 Aprendizaje Autodirigido

Las demandas que el mundo del trabajo impone sobre los profesionales de la ingeniería son muy altas, ya que hoy en día se enfrentan a problemas de gran complejidad, que requieren de ingenieros que continuamente estén aprendiendo para poder resolver los mismos (Bary & Rees, 2006). Estas personas tienen una cualidad que las identifica como aprendices autodirigidos. Ellos tienen las siguientes características: manejan las tareas que tienen que realizar con un sentido de claridad, teniendo en mente los resultados que se esperan de ellos, hacen seguimiento de las tareas para ver cómo están progresando, haciendo uso de estrategias metacognitivas. En caso de que no avancen en la dirección correcta ellos hacen uso de estrategias alternativas para ponerse en el camino apropiado. Además, reflexionan, evalúan, analizan y construyen significados de las experiencias para aplicar ese aprendizaje a futuras actividades, tareas o retos (Costa & Kallick, 2004). En el aprendizaje autodirigido existen cuatro dimensiones interconectadas: El aprendizaje autodirigido es un atributo personal, en el aprendizaje autodirigido los estudiantes tienen el interés por administrar su propio aprendizaje, los estudiantes se transforman en autodidactas y buscan tener nuevos conocimientos fuera del salón de clases y el aprendizaje autodirigido permite organizar la instrucción en los ambientes de aprendizaje formales (Candy, 1991). Como puede verse el aprendizaje autodirigido se lo puede ver desde dos perspectivas como un proceso instruccional y como un constructo de la personalidad (Brockett & Hiemstra, 1991) En esta investigación se consideró el enfoque como producto.

1.2 Paquete de Aprendizaje Autodirigido

El paquete de aprendizaje autodirigido se diseñó de acuerdo al modelo de diseño instruccional de W. Dick y L. Carey. Este modelo comprende las siguientes etapas: Identificar la meta instruccional, esto es que es lo que el estudiante será capaz de hacer cuando finalice la instrucción. Conducir el análisis instruccional, significa determinar qué tipo de aprendizaje se requiere del estudiante. Identificar los comportamientos de entrada, comprende determinar cuáles son los prerrequisitos que el estudiante debe conocer antes de entrar al proceso instruccional. Escribir los objetivos instruccionales, estos se determinan a partir del análisis instruccional e indican lo que los estudiantes serán capaces de hacer cuando finalice la instrucción. Desarrollar las pruebas de criterio por referencia, estas pruebas se diseñan de acuerdo a los objetivos instruccionales presentados. Desarrollar la estrategia instruccional, esta comprende la presentación de la información, práctica y retroalimentación y evaluación. Desarrollar y seleccionar los materiales instruccionales, en esta etapa se selecciona el formato de la instrucción, en este caso se seleccionó el formato impreso. Diseñar y conducir la evaluación formativa, el propósito de esta etapa es identificar los puntos en que hay que mejorar la instrucción. Diseñar y conducir la evaluación formativa, es el punto culminante de la evaluación y sirve para medir la efectividad de la instrucción (Dick & Carey, 1985).

1.3 Aprendizaje Cooperativo

El aprendizaje activo se define como una estrategia instruccional que engancha a los estudiantes en el proceso de aprendizaje mediante actividades diseñadas por el profesor, las mismas que deben cumplirse en el salón de clases (Prince, 2004). Las investigaciones recientes han demostrado que la aplicación del aprendizaje activo en los salones de clase mejora sustancialmente el desempeño de los estudiantes en todas las ramas del conocimiento científico. El aprendizaje cooperativo es un enfoque educativo de aprendizaje en grupos pequeños, que promueve la interacción entre los estudiantes y la responsabilidad por sus propios aprendizajes y el de los demás miembros del grupo. Es oportuno recalcar que el aprendizaje cooperativo es una variante instruccional del aprendizaje activo, cualquier aprendizaje que se de en un entorno cooperativo es un aprendizaje activo, pero no todo aprendizaje activo es cooperativo (Keyser, 2000). El aprendizaje cooperativo implica mayor planificación puesto que requiere que los estudiantes trabajen en grupos estructurados con roles bien definidos, para cumplir una tarea común y mejorar el rendimiento académico. De hecho, las investigaciones han mostrado que efectivamente el aprendizaje cooperativo mejora el rendimiento de los estudiantes (Tien, Roth & Kampmeler, 2002; Felder & Brent, 2007) ya que ellos se involucran activamente en el aprendizaje. Aumentan la motivación por aprender (Tombak & Altun, 2016). Incrementan la responsabilidad del estudiante por su propio aprendizaje. Mejoran las habilidades de colaboración entre los estudiantes (Miller & Groccia, 1997). Incrementan la habilidad para considerar las diferentes perspectivas que presentan los estudiantes (Jacobs, Power & Inn, 2002). Un ejemplo de la práctica del aprendizaje cooperativo se tiene en el aprendizaje basado en problemas (ABP) implementado por la Universidad de Delaware (Allen, Duch y Groh, 2001)

1.4 Juegos estructurados

Los juegos educativos son actividades basadas en reglas que involucran uno o más jugadores con una meta en mente o satisfacer una meta superior, como por ejemplo ganar, porque los mismos son altamente competitivos (Rieber, 2009). Ellos tienen el propósito de incrementar el aprendizaje, enganchar a los estudiantes y son efectivos para aprender a resolver problemas y formar actitudes (Michael & Chen, 2006). Los juegos independientemente de su naturaleza cambian las actitudes de las personas acerca del trabajo y el aprendizaje (Beck & Wade, 2004). Los juegos cambian la situación, de entregar contenido a una de diseñar experiencias, sin embargo, en algunos juegos primero viene la explicación y luego viene la experiencia (Squire, 2006). Los juegos estructurados son actividades que tienen las características críticas de un juego y la característica adicional de ser libres de contenido (Thiagarajan & Pasigna, 1985). Un ejemplo de juego estructurado es el “Chain Gang”, en el cual se utilizan módulos autoinstruccionales para enseñar una habilidad cognitiva. Los juegos estructurados mejoran el autoconcepto de los estudiantes, debido a que ellos tienen la oportunidad de enseñar a otros; apoyan la cohesión del grupo, en razón de todos tienen la misma meta y, además, cambian las habilidades de participación en el grupo ya que ellos tratan de colaborar por el deseo de ganar (Thiagarajan & Pasigna, 1985).

El procedimiento para jugar el “Chain Gang” es como sigue: El profesor presenta el juego, en este caso el juego del cuadrado mágico y muestra algunos ejemplos del mismo. Luego entrega a cada estudiante el módulo instruccional que contiene la regla que ellos tienen que aprender autónomamente y enseñar posteriormente. En este caso hay cuatro reglas por lo tanto hay cuatro módulos autoinstruccionales. Los estudiantes una vez que han aprendido las reglas asignadas se reúnen con los miembros de su equipo para enseñarse mutuamente las reglas que han aprendido, de tal manera que todos ellos aprenden el procedimiento completo. A continuación, se les aplica una prueba de criterio por referencia a los estudiantes para determinar si han aprendido las reglas. En caso de que hayan fallado en la evaluación formativa ellos se reúnen con su grupo para aprender las reglas en que han fallado. Finalmente, se les aplica la evaluación sumativa; los que terminan primero y tienen la solución correcta son los ganadores (Thiagarajan & Pasigna, 1985). Este juego, si bien es cierto que promueve la habilidad de resolver problemas, también promueve las habilidades de cooperación, que en las actividades que siguen los estudiantes las podrán utilizar. Además, es un juego fácil de aplicar y por lo tanto el nivel de aceptación por parte de los estudiantes es alto (Gee, 2004).

1.5 Hipótesis

Las hipótesis describen anticipadamente las relaciones entre las variables y ayudan a enfocarse en el estudio. En este caso la variable independiente es el aprendizaje cooperativo combinado con el aprendizaje autodirigido y la variable dependiente es el rendimiento.

Hipótesis nula

H_0: La media de la prueba de salida es igual a la media de la prueba de entrada. Esto significa que el tratamiento no funciono (Gravetter y Wallnau, 2013).

Hipótesis alternativa

H_1: La media de la prueba de salida es mayor que la media de la prueba de entrada. Esto significa que el tratamiento funciono (Gravetter y Wallnau, 2013).

2 Método

2.1 Sujetos

Participaron en este estudio 24 estudiantes que están registrados en la asignatura de termodinámica que se dicta en la carrera de ingeniería eléctrica de una universidad ecuatoriana. La edad de los estudiantes está comprendida entre los 19 y 21 años.

2.2 Tareas y Materiales Instruccionales

La tarea instruccional seleccionada fue la aplicación de la primera ley de la termodinámica a los procesos isométrico, isobárico, isotérmico y adiabático. La misma que fue presentada en un paquete de aprendizaje autodirigido conformada por cuatro módulos independientes. Este contenido no había sido enseñado a los estudiantes. Además, los módulos autoinstruccionales de las reglas del cuadrado mágico. Entre los instrumentos están la prueba de entrada y de salida que eran iguales y contenían 25 preguntas de múltiple respuesta.

2.3 Diseño experimental

El diseño es un grupo con prueba de entrada y prueba de salida y se diagrama como se muestra a continuación:

$$O_1 \qquad X \qquad O_2$$

Donde O1 representa la prueba de entrada, O2 representa la prueba de salida y la X designa el tratamiento o la intervención (Tuckman, 1988).

2.4 Procedimiento

Esta investigación se realizó en tres sesiones de 2 horas presenciales, durante este tiempo se siguió el procedimiento que se detalla a continuación: (1) Inicialmente se aplicó la prueba de entrada con una duración de treinta minutos. (2) Se formaron los grupos de aprendizaje cooperativo de manera aleatoria utilizando la técnica de las "cartas de naipe", donde los grupos fueron ordenados de acuerdo al número de la carta. Cada grupo estuvo conformado por cuatro estudiantes. (3) Se entregó a cada integrante de los grupos un módulo instruccional que contenía una regla específica para aplicar el "Chain Gang" a la construcción del cuadrado mágico, cuyo procedimiento se explicó anteriormente. (4) Una vez que los estudiantes aprendieron la técnica del "Chain Gang" para familiarizarse con el aprendizaje cooperativo, se procedió a entregar los módulos de aprendizaje autodirigido a los estudiantes de cada grupo, con los procesos termodinámicos para que lo estudien de manera autónoma. (5) Aquellos estudiantes que tenían un módulo en común se reunían para aclarar ciertos puntos de la información proporcionada, y luego regresaban a sus respectivos grupos para explicar aquellos procesos que no habían aprendido. (6) Finalmente se aplicó la prueba de salida.

2.5 Variables

La variable independiente considerada para este estudio es la aplicación combinada del aprendizaje autodirigido y el aprendizaje cooperativo, la variable dependiente bajo análisis, es el desempeño académico de los estudiantes medido por la habilidad para resolver problemas de aplicación de la primera ley de la termodinámica en los procesos isométrico, isobárico, isotérmico y adiabático.

2.6 Análisis Estadístico

Para procesar los datos obtenidos se utilizó el programa estadístico R. La prueba estadística aplicada fue la t emparejada con un nivel de significación $p < 0.05$.

3 Resultados

La Tabla 1 muestra el número de estudiantes, media, mediana, desviación estándar y rango de la prueba de entrada y de salida.

Tabla 1. Datos estadísticos de la prueba de entrada y de salida

Prueba	Numero	Media	Mediana	Desviación Estándar	Rango
Prueba de Entrada	24	6.88	7,00	1,60	4,00
Prueba de Salida	24	19,71	19,00	3,50	10,00

La prueba t emparejada indica que hubo una diferencia significativa entre la prueba de salida y la prueba de entrada ($t = 16{,}37$, $p < 2.2 \times 10^{-16}$).

4 Discusión

Este estudio examino la efectividad de la combinación del aprendizaje autodirigido y del aprendizaje cooperativo en la resolución de problemas de los procesos termodinámicos. La correcta implementación del "Chain Gang" impactó positivamente en los estudiantes, quienes, al familiarizarse con esta técnica, pudieron convertir con éxito esta actividad en una experiencia académica de aprendizaje. Además, el contenido de los paquetes autoinstruccionales estaban bien estructurados y promovían el proceso de conceptualización y de resolución de problemas, que seguido por la aplicación del aprendizaje cooperativo reforzaban los mismos, debido a las explicaciones que los estudiantes se hacían entre ellos. Si bien es cierto que no todos los estudiantes alcanzaron un alto nivel de excelencia como era de esperarse, los resultados presentados confirman que la aplicación combinada del aprendizaje autodirigido y el aprendizaje cooperativo tienen un efecto positivo en el proceso de resolución de problemas de los estudiantes. Una posible explicación para esta situación, es que no todos los estudiantes que entraron al proceso instruccional estaban acostumbrados a aprender autónomamente, sino a recibir las explicaciones por parte del profesor. Además, también merece especial atención el hecho de que no se asignaron roles a los estudiantes durante el trabajo grupal, para que todos se perciban como iguales y de esta manera lograr una mejor interacción social.

5 Conclusión

Este estudio encontró que la intervención aplicada fue satisfactoria para promover el proceso de resolución de problemas de los estudiantes. En consecuencia, este estudio tiene más valor práctico que teórico. Este estudio presenta varias limitaciones, en primer lugar, se trabajó con un grupo intacto, es decir los estudiantes no fueron seleccionados aleatoriamente, en segundo lugar, no se utilizó un diseño experimental apropiado que permita comparar el efecto de la intervención. El arreglo del aula no permitía una interacción cara a cara entre los estudiantes y no había espacio para circular libremente.

Entre las recomendaciones se sugiere revisar el formato de los paquetes autoinstruccionales, en vista de los avances en tecnología computacional se pueden utilizar otros formatos, tales como: videos, simulaciones, animaciones, etc. Además, se sugiere que los profesores que deseen usar estas técnicas, es conveniente que tomen cursos de desarrollo profesional para que las apliquen bien, desde el principio y arreglen el salón de clase para permitir una mejor disposición de los estudiantes al trabajo grupal y una mejor circulación del profesor para observar el trabajo de los estudiantes. Para que los estudiantes mejoren su nivel de desempeño es necesario que los estudiantes interactúen con el profesor (Ericson, Krampe & Tesh-Römer, 1993).

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Application of heuristic method and development of research skills in students in the phase of the research training

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Abstract

The aim of this study was to demonstrate that the application of the heuristic method in the teaching-learning process develops research skills in students in the stage of formative research to students of accounting and auditing of the Faculty of administration of a private University in the city Santiago de Guayaquil. The methodological strategy based on the heuristic method was applied to the experimental group. While the traditional methodological strategy applies to the control group. The number of students in the experimental group was 90 and in the control group was 95. The procedure was in the test for admission of students in the experimental group and the control group. At the end of the speech output test applied to both groups. Input and output test was evaluated using leaves from work and head. Also attended by 5 teachers from grade to which a questionnaire was administered to determine the research skills of students of degree works and 20 students from works of grade that is administered questionnaire to determine the implementation of the research activities. The results indicate that scores before and after applying the heuristic method differ substantially, and this difference is not due to chance. The response to questionnaires indicates that both students and teachers do not have research skills and do not implement activities to develop research skills, respectively. The results allow to accept the hypothesis that the use of the heuristic method is a factor that contributes significantly to the development of research skills. It is recommended to replicate the application of the methodological strategy, looking for activities that promote the actions of the heuristic method.

Keywords: Heuristic method, Formative research, Research skills

Aplicación de Método Heurístico y Desarrollo de Habilidades de Investigación en Estudiantes en la Fase de la Investigación Formativa

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Resumen

El propósito de este estudio fue demostrar que la aplicación del método heurístico en el proceso de enseñanza-aprendizaje desarrolla habilidades de investigación en estudiantes en etapa de investigación formativa a los estudiantes de contabilidad y auditoría de la Facultad de administración de una universidad privada en la ciudad De Santiago de Guayaquil. La estrategia metodológica basada en el método heurístico fue aplicada al grupo experimental. Mientras que la estrategia metodológica tradicional se aplica al grupo de control. El número de estudiantes en el grupo experimental fue de 90 y el grupo control fue de 95. El procedimiento fue en la prueba de ingreso de estudiantes en el grupo experimental y el grupo control. Al final de la prueba de salida de voz se aplicó a ambos grupos. La prueba de entrada y salida se evaluó utilizando hojas de trabajo y cabecera. También participaron 5 profesores de grado a los que se administró un cuestionario para determinar las habilidades de investigación de los estudiantes de trabajos de grado y 20 estudiantes de trabajos de grado que es el cuestionario administrado para determinar la aplicación de las actividades de investigación de los profesores. Los resultados indican que las puntuaciones antes y después de aplicar el método heurístico difieren sustancialmente, y esta diferencia no se debe al azar. La respuesta a los cuestionarios indica que tanto los estudiantes como los profesores no tienen habilidades de investigación y no implementan actividades para desarrollar habilidades de investigación, respectivamente. Los resultados permiten aceptar la hipótesis de que la aplicación del método heurístico es un factor que contribuye significativamente al desarrollo de las habilidades de investigación. Se recomienda replicar la aplicación de la estrategia metodológica, buscando actividades que favorezcan las acciones del método heurístico.

Palabras Claves: Método heurístico, Investigación formativa, Habilidades investigativas.

1 Introducción

La sociedad moderna se encuentra en un contexto que permanentemente está cambiando y esos cambios se producen por las acciones del ser humano, las que contribuyen directamente en ello a través de información que es rápidamente procesada y transformada.

Para que este proceso resulte eficiente y efectivo se requiere de personas que desarrollen habilidades para transformar realidades a través de la investigación formativa como una práctica diaria, en base a aquello se precisa que se aplique métodos que permitan el mayor resultado para mejorar realidades y esto se lo puede desarrollar desde la academia, por ello la necesidad de plantear un estudio como el método heurístico y desarrollo de habilidades de investigación en estudiantes en etapa de investigación formativa para que desde la práctica docente se fomente la investigación científica y contribuir al desarrollo de la sociedad y fomentar desde los conocimientos académicos al cambio de la matriz productiva del país.

En el proceso de enseñanza aprendizaje en la mayoría de las diferentes asignaturas curriculares no se incluye métodos de aprendizaje que busquen desarrollar habilidades de investigación y que permita en el futuro realizar sus trabajos de titulación sin mayores dificultades para luego optar por el título de grado.

Por lo expuesto anteriormente, esto ocasiona que los estudiantes esperen que los docentes tutores prácticamente les elaboren el diseño del proyecto y luego terminen involucrándose más de lo debido en todo el proceso de investigación de su proyecto de grado. En cierta forma es comprensible la actitud de los egresados, ya que para los estudiantes que terminan el ciclo de estudios los términos referentes al proceso de investigación son casi nuevos.

Los estudiantes no están muy familiarizados con la estructura de un proyecto de investigación, esto en gran parte es debido a que en el ciclo de estudios los docentes se enmarcan en cumplir el contenido del syllabus, de tal manera que excluyen un método efectivo que se puede aplicar simultáneamente durante el desarrollo de las clases. El método que se propone busca mejorar las habilidades investigativas de los estudiantes que sin duda alguna en el futuro será una condición sine qua non para la culminación de su carrera.

El propósito de este estudio fue demostrar que la aplicación del método heurístico en el proceso de enseñanza aprendizaje desarrolla las habilidades de investigación en los estudiantes en etapa de investigación formativa a los estudiantes de la carrera de Contabilidad y Auditoría de la Facultad de Administración de una universidad privada de la ciudad de Santiago de Guayaquil.

1.1 Fundamentación del problema de investigación

La Educación Superior (ES) en el Ecuador presenta muchas oportunidades para optimizar el talento humano y los recursos técnicos y tecnológicos. El desarrollo profesional a nivel de los docentes de manera concurrente es evidente y es una gran oportunidad para buscar acciones que permitan fomentar la investigación formativa en los estudiantes durante toda su carrera.

La universidad ecuatoriana apoya esta gestión, lo que genera el deseo de buscar herramientas educativas de enseñanza-aprendizaje que permitan optimizar la formulación de proyectos de investigación de tercer y cuarto nivel para enfrentar y mejorar el desarrollo de procesos investigativos.

De ahí, la importancia de que los profesores a nivel de Educación Superior como agentes de cambio ayuden a los estudiantes a desarrollar las habilidades de investigación durante formación académica.

La formación académica también está bajo la responsabilidad del Estado ecuatoriano, de ahí que el objetivo 4 del Plan Nacional del Buen Vivir (PNBV, 2013) señala:

> *Fortalecer las capacidades y potencialidades de la ciudadanía*. Que tiene entre otras políticas, mejorar la calidad de la educación en todos sus niveles y modalidades, promover la culminación de los estudios en todos los niveles educativos, así como potenciar el rol de los docentes y otros profesionales de la educación como actores en la construcción del Buen Vivir.

El buen vivir es evidenciado en la actuación del ser humano en diferentes aspectos de su vida, en lo que hace o busca hacer. Como indica Hinojosa-Dazza (2015) "el ser humano es intrínsecamente sabio, que busca descubrir cuánto puede dar o cuánto puede hacer". Esta aseveración implica seguir un proceso que también permita dar y hacer lo mejor para ello es necesario apuntar a la formación académica que busque el desarrollo habilidades de investigación de los estudiantes de grado en función de la misión y visión de la institución beneficiaria y que se transfiera a todas las Instituciones de Educación Superior (IES) que buscan generar y difundir los conocimientos a través de la investigación, aplicando modelos pedagógicos actualizados.

En consecuencia, durante su formación académica existe la necesidad de estudiar y aplicar modelos pedagógicos que promuevan en el estudiante el desarrollo de las habilidades de investigación (HI) para mejorar el desempeño de los mismos desde las aulas, esto es lo que se llama investigación formativa, lo que permitirá en el futuro desarrollar con éxito sus proyectos áulicos, trabajos de titulación y tesis de grado y posgrado. En consecuencia, el modelo pedagógico a implementarse durante el desarrollo de la presente investigación es el Método Heurístico (MH).

1.2 Método Heurístico de Landa

Landa, L. N, (1983) indica "El Método heurístico es un proceso que consiste en una serie de operaciones relativamente elementales que son desempeñadas de manera regular y uniforme para resolver todos los problemas de cierta clase", es decir que siguen un procedimiento, a este procedimiento se le llama algoritmo.

Dado que las habilidades investigativas son procedimentales es pertinente aplicar el método heurístico para poderlas desarrollar de manera efectiva

Por lo expuesto el marco teórico para el desarrollo de las habilidades investigativas es el Método heurístico de Lev N. Landa.

El estudio y aplicación del método de estudio propuesto es de interés para todo el claustro universitario, tanto docentes como estudiantes y comunidad en general debido a la utilidad del mismo. Un profesional con habilidades investigativas estará mejor preparado para enfrentar los retos empresariales, académicos, profesionales en cualquier ámbito en el que se desempeñe.

Aunque en el medio no se ha desarrollado el método heurístico para desarrollar habilidades investigativas, en otras áreas del conocimiento si se lo ha aplicado, veamos algunas.

El método heurístico se ha utilizado en diversas áreas del conocimiento, por ejemplo, se aplicó en un estudio de manejo forestal, por ello es que se afirma en este trabajo lo siguiente:

> Los métodos heurísticos tienen un enorme potencial en la resolución de problemas de planificación forestal, en los últimos años han mostrado su efectividad en diferentes aplicaciones, desde problemas de planificación sencillos hasta problemas complejos que no pueden ser resueltos con técnicas clásicas de programación matemática. Además, pueden encontrar buenas soluciones a problemas de grandes dimensiones en un tiempo de computación aceptable. Los beneficios que aportan las técnicas heurísticas se derivan de la posibilidad de resolver problemas de planificación más realistas y menos rígidos que los que se pueden plantear con técnicas derivadas de la programación matemática. (2010, pp. 183-194).

El método heurístico tiene como esencia principal la resolución de problemas, de cualquier índole, de ahí la importancia de considerarlo como una herramienta metodológica en el proceso de enseñanza aprendizaje, para desarrollar las habilidades investigativas de los estudiantes durante su ciclo académico.

El método heurístico también ha sido aplicado en diferentes áreas de la educación, entre ellas en la disciplina de Análisis Químico Cuantitativo de la especialidad de Química, del Instituto Superior Particular "José de la Luz y Caballero", durante el curso 2001-2002, en los estudiantes de 4to. Año de Carrera de Química, como prácticas de laboratorio se rediseñaron a partir del Sistema de Habilidades Experimental.

Los resultados obtenidos a partir de la aplicación del método heurístico, permitió constatar que los procesos problémicos que con mayor grado presentaron los estudiantes fueron los siguientes: análisis cualitativo de la situación problémica, internacionalización del problema, formulación de hipótesis, diseño y selección de procedimientos de solución, control de procesos y de la solución de problemas, como lo indica Basulto, L.,Estévez,M., Bernal,O. (2006).

Se consultó una investigación, dirigida por el doctor Francisco García, correspondiente a una tesis doctoral presentada por Miguel Baños González para comprobar si la utilización del método heurístico permite incentivar la creatividad en la producción de ideas publicitarias, se escogió a los profesionales de la creación publicitaria, comparándolos con profesionales que no se dedicaban a esta tarea, el estudio fue llevado a cabo en la evaluación de las ideas producidas por cada uno de los dieciocho grupos de trabajo que se reunieron para realizar la tarea.

Según Baños, M.(2009). Los resultados señalaron que "los grupos creativos generan mayor fluidez, flexibilidad, originalidad, elaboración, coherencia interna y adecuación, cuando utilizan un método heurístico durante el proceso de creación publicitaria"

De acuerdo a indagaciones realizadas por la autora en la universidad donde se aplicó el método heurístico, hasta el momento no se ha llevado a cabo un estudio de la presente propuesta sobre el método heurístico como una herramienta metodológica de mejoramiento académico

Hipótesis Alternativa
La aplicación del método heurístico es un factor que contribuye significativamente en el desarrollo de habilidades de investigación de estudiantes en etapa de investigación formativa de la carrera de Contabilidad y Auditoría en la universidad (G1).
Hipótesis Nula
Con la aplicación del Método Heurístico no hay diferencia en cuanto al desarrollo de las habilidades de investigación en los estudiantes del grupo de control y en los estudiantes del grupo experimental.

2 Método

2.1 Sujetos

Participaron en este estudio 243 estudiantes, 90 estudiantes del grupo experimental, 43 estudiantes del quinto semestre A diurno, 14 hombres y 29 mujeres; 47 estudiantes del quinto semestre A nocturno, 18 hombres y 29 mujeres. Del grupo de control participaron 95, 45 estudiantes de quinto semestre B diurno, 15 hombres y 30 mujeres, 50 estudiantes de V semestre B nocturno, 13 hombres y 33 mujeres de la Carrera de Contabilidad y Auditoría de una universidad privada de la ciudad de Santiago de Guayaquil, quienes recibieron la asignatura de Marketing Estratégico, según la malla curricular de los estudiantes de la Facultad de Administración de la universidad en donde se realizó el estudio, entre el periodo 2015-2016.

2.2 Tareas y materiales instruccionales

La institución denominada G1, está ubicada en la ciudad de Guayaquil, correspondiente al Distrito Tarqui 2 09D05C01- Circuito Guayaquil-Atarazana de la Zona 8 de acuerdo a la distribución realizada por la Secretaría Nacional de Planificación y Desarrollo (SENPLADES).

Se trabajó con el método heurístico que implica la aplicación de los indicadores establecidos durante el primer semestre del 2015, con 96 sesiones, cada sesión de una hora de sesenta minutos, las clases se desarrollaron en 6 horas a la semana, dos horas cada día, lo cual permitía trabajar con casos prácticos, se desarrolló un caso en cada clase con actividades que implica la aplicación del método heurístico.

El grupo de control, lo constituyó 95 estudiantes, 45 del paralelo B diurno y 50 del paralelo B nocturno. El paralelo B diurno, tenía 15 hombres y 30 mujeres, y el paralelo B nocturno tenía 13 hombres y 33 mujeres, con edades comprendidas entre 20 y 26 años. Este grupo recibió las clases de Marketing Estratégico de manera tradicional. En este caso no se aplicó el MH, y se trabajó con el mismo instrumento para evaluar las habilidades investigativas.

2.3 Instrumentos

- **Hoja de trabajo**

El propósito de la hoja de trabajo fue verificar la presencia o ausencia de los indicadores de logros en lo que respecta al desarrollo de las habilidades de investigación en la etapa formativa. Los indicadores están expresados como: alto, medio bajo. Los estudiantes que obtuvieron un puntaje entre seis y cinco, están en el rango de alto. Los estudiantes que obtuvieron un puntaje entre cuatro y tres, están en el rango de medio y los estudiantes que obtuvieron un puntaje entre dos y uno están en el rango de bajo, lo que se verifica en el Anexo 3.1.

La hoja de trabajo consta de 16 ítems para evaluar un problema o caso planteado por el docente. Esta hoja de trabajo se utilizó para evaluar tanto la prueba de entrada como de salida del grupo de control y experimental.

- **Rubrica**

Para cotejar la veracidad de los resultados obtenidos en la aplicación de la prueba de entrada y salida expuesta en las hojas de trabajo, se diseñó una rúbrica que constituye las dimensiones e indicadores de la operacionalización de las variables. La evaluación se basa en criterios que permiten determinar los niveles de desarrollo de las habilidades investigativas. Esto significa que hay niveles alto, medio y bajo. Según el nivel más alto le asignó un puntaje de entre 6 y cinco, nivel medio un puntaje de entre cuatro y tres y el nivel bajo el puntaje entre dos y uno.

- **Cuestionario dirigido a estudiantes de trabajos de titulación**

El cuestionario dirigido a los estudiantes de trabajos de titulación tuvo como propósito determinar si los estudiantes consideraban que sus docentes habían desarrollado actividades metodológicas en sus respectivas asignaturas, en las que se evidenciaba habilidades de investigación, como consta en el cuestionario de 18 preguntas. Este cuestionario fue contestado por 20 estudiantes.

- **Cuestionario dirigido a los docentes de trabajos de titulación**

El cuestionario dirigido a los docentes de trabajos de titulación tuvo como objetivo verificar si los estudiantes que ellos recibían una vez egresados de la carrera demostraban habilidades de investigación, a través del cuestionario administrado de 18 preguntas, las mismas que fueron consideradas por estudiantes de la carrera. Este cuestionario fue contestado por cinco docentes.

2.4 Procedimiento

El procedimiento para esta investigación fue el siguiente: (1) Administrar la prueba de entrada a los estudiantes del grupo experimental y grupo de control. Para la prueba de entrada se utilizaron las hojas de trabajo que posteriormente se evaluaron con una rúbrica.

Ambos grupos recibieron el mismo contenido de la asignatura Marketing Estratégico durante el semestre. Las clases tuvieron una duración de dos horas de sesenta minutos a la semana. (2) Se aplicó el Método Heurístico al grupo experimental y el Método Tradicional al grupo control. (3) Se administró la prueba de salida a los estudiantes del grupo experimental y de control. La prueba de salida fue evaluada con la rúbrica. (4) Se administró el cuestionario de habilidades de investigación (CHI) para los estudiantes y para los profesores de trabajos de titulación, se trató del mismo cuestionario, aunque de diferente audiencia, se tardaron entre 15 y 20 minutos respectivamente.

2.5 Diseño de la investigación

La presente investigación se condujo mediante el enfoque cuantitativo siguiendo el presente diseño: grupo experimental (GE) y grupo de control (GC). Con prueba de entrada (PE) y prueba de salida (PS).

O_1	X	O_2
0_3		O_4

3 Resultados

Se ha realizado una prueba de hipótesis para muestras dependientes para la media poblacional cuando la desviación estándar poblacional es desconocida.

Se desean comparar las calificaciones obtenidas a 95 estudiantes que conforman el grupo de control y 90 estudiantes que conforman el grupo experimental, tanto antes de aplicarle el método heurístico como después de aplicar dicho método.

Con un nivel de significancia de 0.05 se va probar que hay una diferencia significativa entre las calificaciones obtenidas por los estudiantes en la prueba de salida después de aplicar el método heurístico y el método tradicional.

Para analizar los datos (calificaciones) del Grupo de Control se utiliza en este apartado el software SPSS v24 (Statistical Package for the Social Sciences – Paquete estadístico para Ciencias Sociales).

En SPSS, se definen 2 variables que representan las calificaciones en el test realizadas a estudiantes al inicio del semestre y al finalizar el semestre. A estas variables se las ha llamado ANTES y DESPUÉS.

Grupo de Control
La calificación obtenida al aplicar la prueba al inicio del semestre se ilustra de manera gráfica mediante un Histograma de Frecuencias en la Figura 1

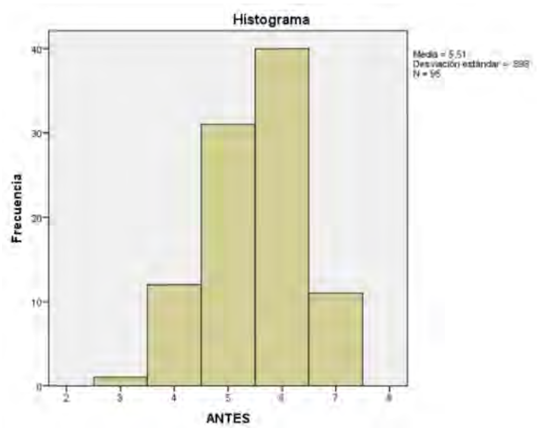

Figura 1. Histograma de las calificaciones

La calificación obtenida al aplicar la prueba al inicio del semestre se ilustra de manera gráfica mediante un Histograma de Frecuencias en la Figura 2

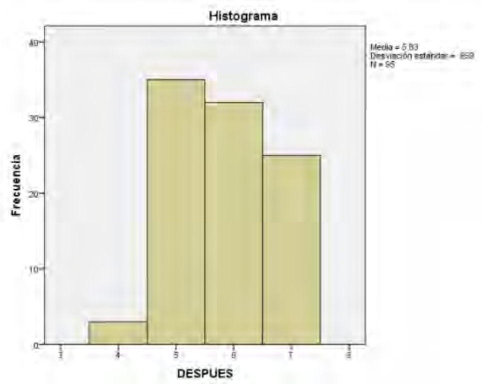

Figura 2. Histograma de las calificacion

4 Discusión

Se observa que las medias de la prueba de entrada de ambos grupos no son tan muy apartadas por lo tanto se puede concluir que son grupos semejante o iguales.

También se observa que la ganancia entre la media de la prueba de entrada y salida del grupo de control es de 0. 30, mientras que la ganancia entre las medias de la prueba de entrada y salida del grupo experimental es 4,03. Además, la desviación estándar de la prueba de entrada es semejante para ambos grupos.

El histograma de la prueba de entrada muestra que las calificaciones están distribuidas simétricamente, mientras que las calificaciones de la prueba de salida están sesgadas negativamente.

Los resultados estadísticos muestran que el método heurístico es más apropiado para desarrollar las habilidades investigativas de los estudiantes, que el método tradicional.

5 Conclusiones y recomendaciones

El Diagnostico de la situación actual a nivel de Educación Superior con respecto a las habilidades de investigación que presentan los estudiantes durante la etapa formativa, ha sido interesante sobre todo porque para los involucrados no conocían del tema.

Al validar la estrategia didáctica metodológica con base en el método heurístico que guíe el desarrollo de las habilidades de investigación se demuestra la relación causal entre la aplicación del método heurístico y el desarrollo de habilidades de investigación en estudiantes en etapa formativa de Carrera de Contabilidad y Auditoría de una universidad privada de la ciudad de Guayaquil.

Este estudio demostró que la aplicación del método heurístico para la enseñanza de las habilidades investigativas de los estudiantes mejoró significativamente su desempeño. Este método requiere que los estudiantes realizaran lecturas regulares del contenido y mostraron cierta resistencia a esta actividad, sin embargo, luego se sintieron motivados por el aprendizaje que realizaron.

Al Sistematizar los referentes teóricos-metodológicos, sobre el método heurístico y habilidades de investigación se apreció como estas referentes, este tema ha sido evidentemente nuevo, no existeprecedentes de trabajos relacionados a la formación de habilidades de investigación de los estudiantes universitarios con la aplicación del Método heurístico.

Se pudo determinar a partir de un estudio empírico, es decir pruebas estadísticas y de aplicación del programa Statistical Package for the Social Sciences (SPSS), la incidencia significativa que tiene la aplicación del método heurístico en el desarrollo de las habilidades de investigación en estudiantes en etapa formativa.
A partir de los resultados se demuestra que la aplicación del método heurístico en el proceso de enseñanza aprendizaje, si desarrolla las habilidades de investigación de los estudiantes en etapa de investigación formativa, lo que contribuye significativamente el en el perfil se salida de los estudiantes, para incentivo de propuestas productivas para para planificar proyectos de emprendimiento o de inversión

Se pudo determinar mediante los resultados de la aplicación de la estrategia metodológica con base en el método heurístico a través de observación directa, aplicación de hojas de trabajo, rúbricas de evaluación, aplicación de cuestionarios a diferentes grupos involucrado directamente en la investigación el entusiasmo e interés de los estudiantes por aprender mediante este método.

En el cuestionario planteado a los estudiantes para que evalúen a los profesores se pudo evidenciar que ellos no tienen un conocimiento profundo del método científico, debido a que la mayor parte de su ejercicio docente se ha concentrado en la enseñanza de los contenidos, más no en los procesos de investigación propios de su carrera.

Queda demostrado a través de un proceso investigativo exhaustivo y concienzudo que la aplicación del método heurístico como estrategia metodológica permite mejorar el desarrollo de las habilidades de investigación de los estudiantes en las universidades de Guayaquil sean ésta públicas o privadas.

De ahí que aquellos estudiantes a los que se les aplicó el método heurístico en la etapa de investigación formativa desarrollan significativamente habilidades de investigación que aquellos estudiantes que no se les aplicó el método.

Entonces, es evidente que SI hay diferencia en cuanto al mejoramiento de las habilidades de investigación de los estudiantes que reciben las clases con actividades académicas basadas en el método heurístico y de aquellos estudiantes que no reciben las clases con actividades en las que se aplica el método heurístico.

Trabajar con diagnósticos permanentes para conocer los avances o situación actual de las Instituciones de Educación a nivel Superior que permitan reconocer las falencias o las fortalezas respecto a las habilidades de investigación que presentan los estudiantes durante la etapa formativa.

Aplicar la investigación formativa en las instituciones de Educación Superior del país. Se debe trabajar con temas que relacionen con métodos que desarrollen las habilidades investigativas de los estudiantes de la carrera de Contabilidad y Auditoría y otras carreras del claustro universitario.

Diseñar y desarrollar cursos del método heurístico a los profesores de las diferentes carreras. Socializar las ventajas que presenta la aplicación del método heurístico en los diferentes procesos de enseñanza aprendizaje para mejorar las habilidades investigativas de los estudiantes y reforzar los conocimientos de los docentes.

Dada la incidencia significativa que tiene la aplicación del método heurístico en el desarrollo de las habilidades de investigación en estudiantes en etapa formativa, es decir durante su estancia educativa, dentro del claustro universitario se debe socializar los resultados que produce su aplicación.

Publicar los estudios realizados a partir de los resultados que demuestren que la aplicación del método heurístico en el proceso de enseñanza aprendizaje si desarrolla las habilidades de investigación de losestudiantes en etapa de investigación formativa y que además contribuye significativamente en el perfil se salida de los estudiantes, para incentivo de propuestas productivas para para planificar proyectos de emprendimiento o de inversión.

Mejorar las estrategias didácticas metodológicas que permitan el desarrollo de habilidades investigativas basadas métodos que impliquen actividades heurísticas validadas, a través de experimentaciones en las aulas de clases de diferentes entidades de Educación Superior para el favorecimiento del desarrollo de las habilidades de investigación de estudiantes en etapa formativa.

Replicar la aplicación de la estrategia metodológica en grupos experimentales, buscando otras actividades que favorezcan las acciones propias del método heurístico como elemento que desarrolle las habilidades de investigación y que incidan positivamente en los estudiantes.
Promover en los talleres de titulación actividades que desarrollen las dimensiones establecidas en este estudio como, por ejemplo: observación, identificación, definición del problema, selección, sistematización de las variables, presentación de metodología para la solución del problema, redacción del marco teórico, formulación del problema, hipótesis y operacionalización de las variables, lectura y escritura analítica.

Realizar durante los ciclos de estudios procesos investigativos exhaustivos y concienzudos con la participación activa de los estudiantes, que finalmente presenten una propuesta de investigación.

Empoderarse del desarrollo de habilidades investigativas en las diferentes asignaturas y no delegar esa función a las asignaturas tradicionales, como técnicas de investigación, proyectos de investigación, metodología de la investigación y afines a la tarea de enseñar a investigar, se debe lograr que los estudiantes de nivel superior desarrollen sus habilidades investigativas durante el proceso, ya que se considera que debe ser tarea de todos. Continuar con la mística docente de buscar las herramientas didácticas que busque mejorar la calidad de la educación universitaria. Seguir soñando con una universidad de valores y de acciones, centrada en el desarrollo del ser humano y sus capacidades para "aprender a emprender" con visión de "investigar investigando". Con el anhelo de que el presente trabajo sea un efecto multiplicador para generar investigaciones que busquen permanentemente la mejora continua en la educación ecuatoriana.

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Implementation of the conceptual model to assess project-based learning

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Abstract

The research describes the results obtained from the design and implementation of a conceptual model in order to evaluate learning with a focus on PBL (Project Based Learning). The framework project incorporated a conceptual approach. The proposed conceptual design includes the knowledge, skills and key competences for students to analyze the solution alternatives to a real case. Other related strategies were: reflexive autonomous learning and cooperative work. The key elements for the evaluation process are: didactic planning, activity scheduling, phase-based evaluation rubrics, online platform, start and end surveys, as well as three evaluation approaches. The results suggest important findings using descriptive statistics tools and multivariate methods. 80% of the students positively evaluated the structure of the project, as an excellent platform to improve their leadership profile, since it allowed them to improve their decision-making skills. 72% said that the project was stimulating, strengthened the initiative to study and implement improvement alternatives, as well as demonstrate enthusiasm and confidence towards new challenges. Today, the project continues in its fourth edition during the academic cycle from January to June 2018. Future works will be focused on exploring new findings incorporating alternative factors such as: commitment, responsibility and initiative.

Keywords: Project-based learning; Autonomous Learning; Team work..

Implementación de un modelo conceptual para evaluar el aprendizaje basado en proyectos

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Resumen

La investigación describe los resultados obtenidos a partir del diseño e implementación de un modelo conceptual para evaluar el aprendizaje orientado al PBL (Project Based Learning). El proyecto marco incorporó un enfoque conceptual, cuyo diseño permitió que los estudiantes pusieran en práctica sus conocimientos, habilidades y competencias, para evaluar las alternativas de solución a un caso típico de la vida real. Otras estrategias de enseñanza fueron: el aprendizaje autónomo reflexivo y el trabajo cooperativo. Como insumos al proceso de evaluación incorporamos: la planeación didáctica, el calendario de actividades, rúbricas de evaluación por fases, la plataforma en línea para el acceso a los contenidos del curso, encuestas de entrada y de salida, así como tres enfoques de evaluación. Los resultados sugieren hallazgos importantes empleando herramientas de estadística descriptiva y métodos multivariantes. Donde el 80% de los estudiantes encuestados evaluaron positivamente la estructura del proyecto como una excelente plataforma para mejorar su perfil de liderazgo, ya que les permitió mejorar sus competencias para la toma de decisiones. El 72% refirió que el proyecto les permitió poner a prueba su iniciativa para explorar alternativas de mejora, demostrar su entusiasmo y confianza hacia los retos que se le presentaron. Hoy día el proyecto continúa en su tercera edición durante el ciclo académico Enero-Junio de 2018. Futuras investigaciones nos orientan a explorar nuevos hallazgos incorporando a los análisis, factores alternos como: el compromiso, la responsabilidad e iniciativa.

Keywords: Aprendizaje basado en proyectos; Aprendizaje autónomo, Trabajo colaborativo.

1 Introducción

La motivación de la investigación subyace en la necesidad de fortalecer el desarrollo de competencias en los estudiantes en el marco de la propuesta e implementación del Modelo Educativo para la Formación Integral (MEFI) en la Universidad Autónoma de Yucatán (UADY). La investigación propuso la utilización de diversas tecnologías y el diseño de materiales pertinentes para la construcción del aprendizaje en la modalidad presencial. La asignatura intitulada Mediciones en Ingeniería fue el marco para la implementación y la documentación de experiencias de enseñanza-aprendizaje. La configuración del curso establece sesenta y cuatro horas presenciales y un igual número para las no presenciales. El modelo marco para la formación de los estudiantes en la disciplina, estuvo acompañado de la plataforma en línea, UADY-Virtual (FIQ, 2016), (véase Figura 1), la cual permitió la administración de los recursos, la gestión de las actividades de aprendizaje e implementar las encuestas de inicio, intermedia y al finalizar el curso, siendo una de las fases clave para el seguimiento académico de los estudiantes.

Figura 45. Plataforma uady virtual.

2 Objetivo

El propósito de la conceptualización y por ende la sistematización del proceso de evaluación del aprendizaje, ha sido generar un marco metodológico que nos permitiera documentar de forma sistemática los datos en diferentes etapas (véase Figura 2), y obtener información pertinente y valorar el impacto del PBL. Siendo tres fases las que conformaron la investigación. La primera, diseñamos la planeación didáctica, los instrumentos de evaluación mismos que se sometieron a análisis de consistencia mediante un grupo de expertos, finalmente configurar los contenidos en la plataforma virtual. La segunda fase, consistió en la articulación e implementación del proyecto integrador. Sentamos las bases del modelo marco para los análisis multivariantes. La última fase incorporó los tres enfoques de evaluación. Misma que sirvió de base para desarrollar una metodología de evaluación para proyectos integradores.

Además, documentar las experiencias y lecciones aprendidas derivadas de las diferentes fases del proceso, hemos puesto un especial interés a algunos de los beneficios que sugiere (Saenz, 2012), siendo:

- Permitir la recolección, la organización, la síntesis, la utilización y el compartir el conocimiento local y científico presentes en un proyecto.
- Desarrollar la capacidad de aprendizaje de los participantes.
- Promover la participación y empoderamiento de los actores que intervienen en el proyecto.

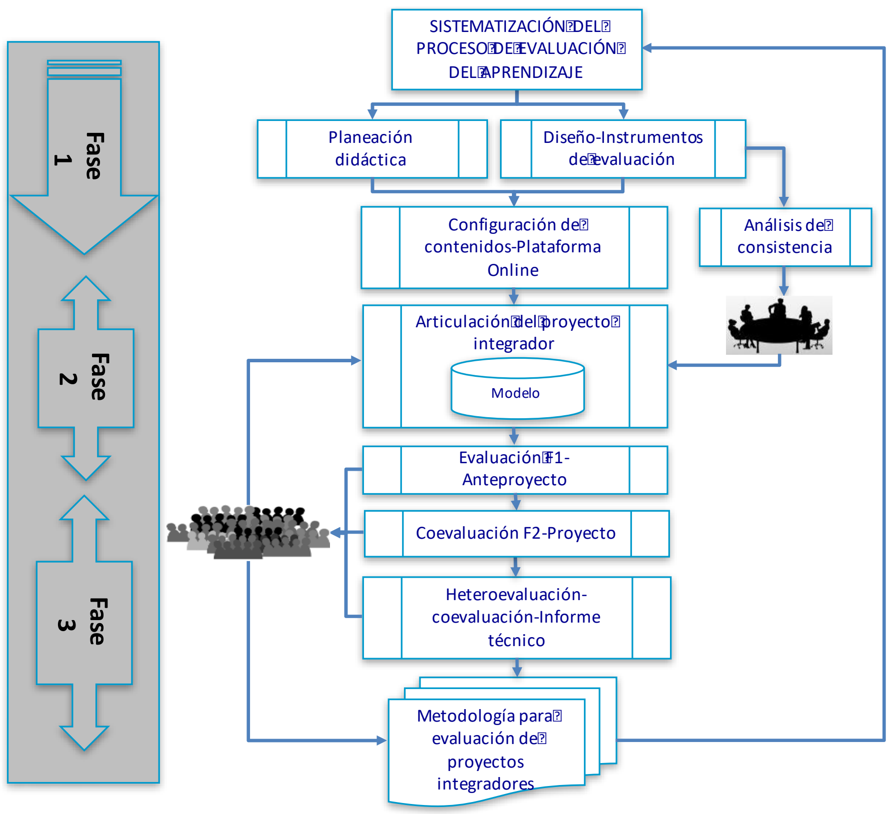

Figura 46. Modelo conceptual para la evaluación del aprendizaje.

2.1 Aprendizaje basado en proyectos

Por otra parte (Gessa, 2011) señalan que proveer un adecuado sistema de aprendizaje, los estudiantes aprenden a asumir la función formativa, supervisando ellos mismos lo que aprenden. Sin embargo, la facción sumativa no puede desligarse porque de alguna forma se debe comprobar hasta qué punto los evaluados han aprendido lo que se supone deben aprender

Los modelos utilizados tradicionalmente centran la evaluación en cogniciones aisladas sin considerar su conexión con el marco de conocimientos general y personal del alumno, esta tendencia no favorece la construcción del conocimiento y se vuelve obsoleto para las tendencias y necesidades actuales en la educación.

Un modelo de evaluación que encaja con el PBL es aquel por competencias. Éste se orienta a evaluar las competencias en los estudiantes teniendo como referencia el desempeño de estos ante las actividades y problemas del contexto profesional, social, disciplinar e investigativo. Esto privilegia el desempeño del estudiante ante actividades reales o simuladas propias del contexto. De igual manera ofrece resultados de retroalimentación cuantitativa, así como cualitativa según (Brown & Pickford, 2013). A continuación, se formulan algunas reflexiones que enmarcaron el trabajo de investigación:

1. ¿Qué características debería tener el escenario de aprendizaje que contribuya al desarrollo de competencias?
2. ¿El juego de roles es una dinámica significativa para la formación del liderazgo?

Partiendo de estas reflexiones declaramos como objetivo de investigación evaluar el alcance y los resultados del modelo propuesto para la sistematización del proceso de evaluación del Aprendizaje Basado en Proyectos como instrumento para la formación de líderes.

3 Materiales y métodos

3.1 Materiales

Para el análisis de los resultados utilizamos el software RStudio (versión 0.99.491). El acopio de los datos analizados corresponde a un conjunto de variables que se obtuvieron durante la evaluación de salida al finalizar la implementación del proyecto. El instrumento recoge las variables de Liderazgo (L), Edad (E), Rol (R) y el Semestre (S), este último denota el grado equivalente de los participantes que se matricularon al curso. Cada grupo de análisis se caracterizó y a su vez responde a un rol que desempeñó durante todo el proyecto.

3.1.1 Diseño de la herramienta para el acopio de información

Los instrumentos de evaluación antes de ser empleados fueron valorados por profesionales expertos del área, mediante la plataforma en línea durante el mes de octubre del 2016, justo al inicio del curso.

A través de los pre test se verificaron la coherencia semántica y discriminación de aquellos reactivos que resultaron confusos o inconsistentes. La encuesta de salida incluyó el perfil del participante, 6 reactivos relacionados al liderazgo (véase la Tabla 1) acorde a una escala de Likert. También se incorporó una sección relacionada con la experiencia previa del participante en proyectos afines, el cumplimiento de sus expectativas al finalizar el proyecto, entre otros aspectos vinculados con la dinámica del proyecto.

Tabla 24. Perfil de liderazgo.

Factor	Descripción
Liderazgo	Dirigir e implicar a las personas, tomando decisiones responsables, para conseguir los objetivos comunes asumiendo las responsabilidades y los riesgos.
Iniciativa	Demostré capacidad para idear, inventar o emprender con entusiasmo hacia los retos que se me presentaron.
Compromiso	Demostré fuerte y constante compromiso en el desarrollo de mi propio conocimiento y en las metas como grupo.
Responsabilidad	Atendí en tiempo y forma a las actividades y reuniones programadas.

3.1.2 Dimensiones de la evaluación

La herramienta se diseñó en tres dimensiones, la primera responde al acopio de datos cuantitativos para estudiar la estructura, organización y el alcance del proyecto integrador como agente catalizador para la formación del liderazgo ante situaciones que impliquen la toma de decisiones, además de que impulsen los cambios sustanciales al proyecto tipo, tales como: la implementación de un programa de mejora continua y por ende la búsqueda de soluciones alternativas.

La segunda dimensión fue útil para determinar en qué medida el proyecto fortaleció el perfil de liderazgo, en contraste con los indicadores de desempeño declarados en el objetivo marco del proyecto (véase la Figura 1). La tercera dimensión valora el compromiso, la responsabilidad e iniciativa del estudiante ante los retos que demanda un proyecto con estas características.

3.2 Métodos

El objetivo principal de los siguientes métodos es analizar la estructura común de las distintas tablas de datos, poniendo de manifiesto cuáles son los elementos heterogéneos, es decir diferentes al resto. Además de los resultados clásicos las medidas globales de relación entre los grupos, permiten cuantificar la semejanza global existente entre ellos con indicadores parciales de acuerdo con la metodología de (Bécue-Bertaut & Pagès, 2008).

3.2.1 Análisis factorial múltiple (AFM)

Es un método factorial que permite el análisis simultáneo de varios grupos de variables dado un conjunto de individuos véase (Abdi, Williams, & Valentin, 2013) y (Escofier, 2003). El AFM es considerado como un Análisis de Componentes Principales ACP, dada la influencia y equilibrio entre los grupos y las variables, éstas últimas pueden ser diferentes incluso en naturaleza y número. La única restricción es que las variables que integran un grupo sean de la misma naturaleza, cuantitativa o cualitativa. El AFM tiene como objetivo comparar las tipologías de los individuos a nivel global y grupal. El objetivo del análisis es valorar la estabilidad de los resultados obtenidos en un ACP. La estructura de los datos parte de una tabla X compuesta de I filas y K columnas que proporcionan cada uno de los i individuos de una población de las medidas de K variables. Los pasos para este análisis son los siguientes:

1. Análisis parcial. Efectúa un ACP normado de cada tabla de datos (k=1, ..., K) y retiene el primer valor propio de cada una de ellas.
2. Análisis global. Realiza un ACP de la tabla global que resulta de yuxtaponer todas las tablas, a las que previamente a cada una se las ponderó por el inverso del primer valor propio obtenido en la primera etapa. Mediante esta ponderación es posible mantener la estructura de cada tabla, ya que todas las variables han recibido la misma ponderación, pero consigue equilibrar la influencia de los grupos, ya que la inercia máxima de cada una de las nubes de individuos definida por los distintos grupos, con valor de 1 en cualquier dirección.

El coeficiente RV puede ser utilizado como medida de similitud entre dos configuraciones; se define como el producto escalar entre pares de matrices (el producto de Hilbert-Schmidt), (véase también (Lebart, L., Salem, A., 2000) & (Pagès, 2004); este producto escalar induce una norma y, por lo tanto, una distancia. Si la correlación vectorial entre dos matrices es igual a la unidad, eso significa que ambas matrices son equivalentes en el sentido de que ambas estructuras son congruentes, es decir cuanto más próximo a uno, más similares serán las estructuras. En contraste, si los resultados son iguales a cero significa que no existe relación entre las variables de los dos grupos considerados. Esta medida es completada con los coeficientes Lg que pueden ordenarse en una matriz de orden KxK y que miden la dimensionalidad (número de factores de inercia considerable) de cada grupo.

4 Resultados

La población la conformaron 65 estudiantes de las asignaturas Ingeniería de Métodos y Mediciones en Ingeniería. La dinámica de roles se caracterizó por actividades orientadas hacia dirección y supervisión. La Tabla

2 describe otras características relevantes respecto al perfil de los participantes, grupos y semestres equivalentes, ambos pertenecientes al modelo educativo para la formación integral (MEFI) véase (FIQ, 2016).

Tabla 25. Estadística descriptiva del perfil de la muestra.

Género		Roles		Edad		Semestre	
Hombres	16	Dirección	30	Min	18	Min	4
Mujeres	33	Supervisión	19	Media	22	Mediana	4
				Max	25	Max	7

De acuerdo a la encuesta de inicio del curso el 58% de los participantes refirió no haber tenido experiencia previa participando en proyectos integradores relacionados con la implementación de programas de mejora continua. Respecto a si la configuración del proyecto les permitió cumplir sus expectativas (CE), así como si la configuración y estructura del proyecto integrador les resultó estimulante (E), ambos rubros fueron valorados positivamente con un 92%. La Figura 3 describe otros aspectos importantes relacionados con la estructura del proyecto integrador.

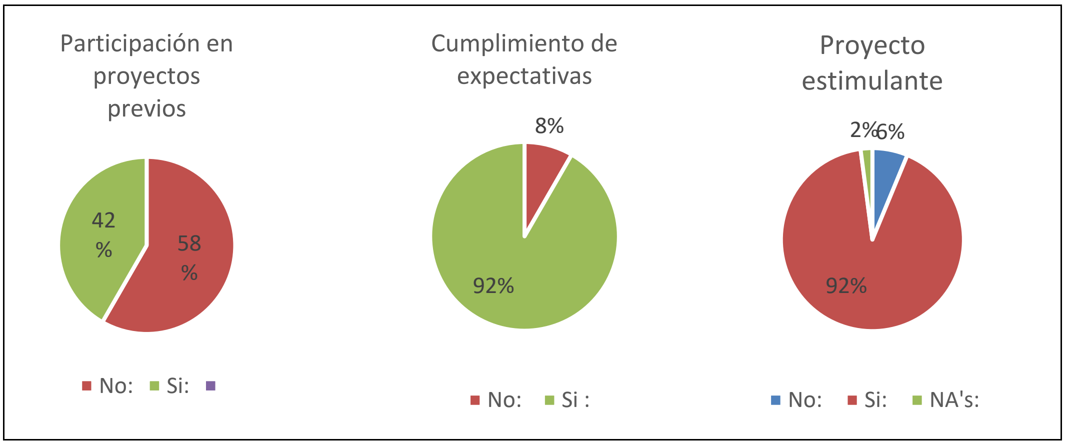

Figura 3. Resultados del proyecto integrador.

Cada grupo de análisis se caracterizó y a su vez responde a un rol que desempeñó durante todo el proyecto, por lo que los roles (R) de la matriz de datos resultante que la conforman son: Supervisión y Dirección que se ilustran en la Figura 4. Asimismo, se observan las variables complementarias como: Liderazgo (L), Edad (E), y el Semestre (S).

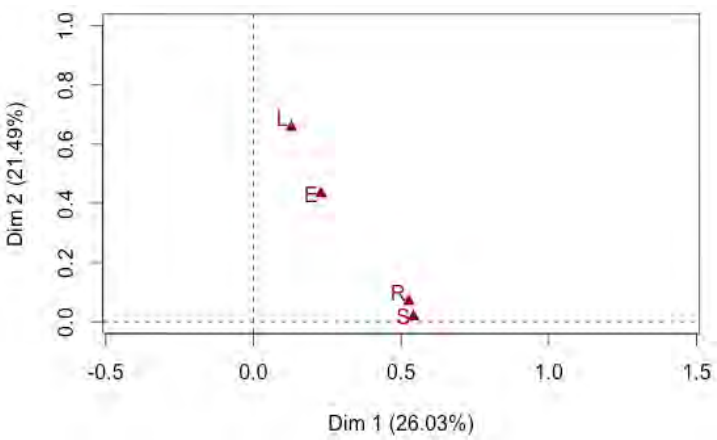

Figura 4. Grupos de variables de análisis

La figura 5 describe la representación de la nube de puntos para cada grupo de análisis y la similitud entre sus estructuras internas de acuerdo a cada una de las dimensiones. Es decir, cada uno de los puntos refiere la interacción y comportamiento de las variables respuesta y las relaciones con las variables latentes. Se puede pueden observar que todas están bien representadas en cada eje.

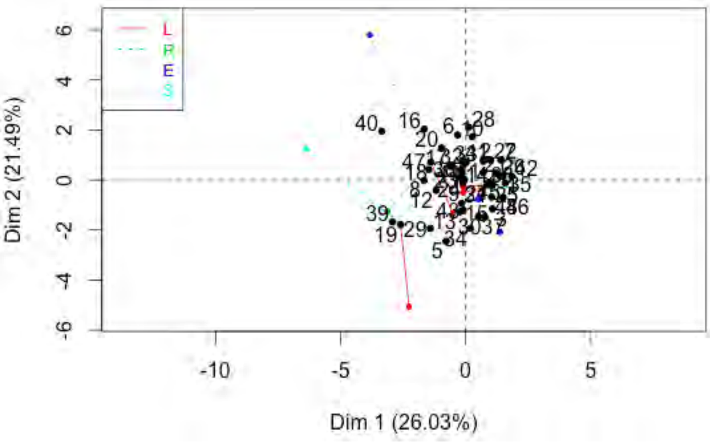

Figura 5. Nube de puntos

De acuerdo a la etapa 1 descrita en la Figura 2, realizamos un ACP normado sobre cada tabla de datos. En la figura 6 se describen los doce autovalores siendo el primero el más importante y de mayor representatividad. Por lo cual los primeros resultados de salida nos permitieron concluir que el 85% de las variables se explican y corresponden a los primeros cinco componentes. Esta característica es relevante para el estudio ya que nos permite discriminar los primeros ejes factoriales, seguidamente analizar su impacto y su correlación.

	Autovalor	% Var	% Var Acum
comp 1	1.424	26.028	26.028
comp 2	1.176	21.489	47.517
comp 3	0.930	17.005	64.523
comp 4	0.669	12.234	76.757
comp 5	0.477	8.712	85.470
comp 6	0.299	5.471	90.940
comp 7	0.227	4.153	95.093
comp 8	0.158	2.880	97.973
comp 9	0.111	2.027	100.000
comp 10	0.000	0.000	100.000

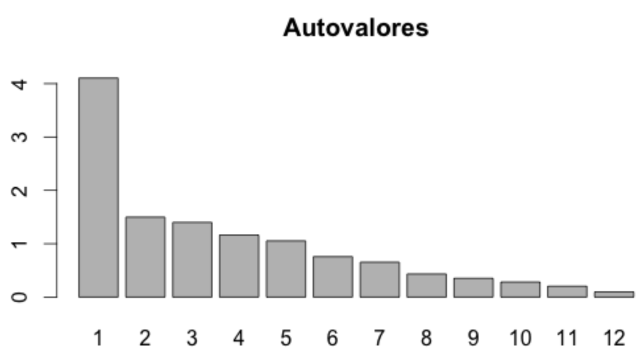

Figura 6. Autovalores globales

Para analizar la correlación entre los factores parciales de cada una de las variables y las componentes principales donde los resultados de salida los resumimos en la Tabla 3. En ella se observa que en el primer eje están representadas las principales características, semejanzas y diferencias de las variables: Liderazgo (0.621), Rol (0.652) y el Semestre (0.890). En el segundo eje lo conforman la Edad (0.874) como la predominante, en el eje 3 nuevamente el Liderazgo (0.877) y el Rol (0.576) entre los más importantes. Para este trabajo de investigación hemos discriminado los últimos tres componentes, ya que las variables están representadas particularmente en los primeros dos componentes.

Tabla 3. Coeficientes de correlación entre los factores parciales

	Eje 1	Eje 2	Eje 3	Eje 4	Eje 5
L	0.621	0.594	0.877	0.433	0.735
R	0.652	0.421	0.576	0.777	0.713
E	0.173	0.874	0.244	0.320	0.059
S	0.890	0.186	0.008	0.343	0.111

El coeficiente RV resultó ser igual a 0.618, por lo que inferimos que los roles Dirección y Supervisión presentan una estructura con más similitudes que diferencias. Los resultados de la matriz de coeficientes Lg indican que las variables están relacionadas, por lo que el análisis de los vectores-variables están fuertemente referenciados en el primer eje global.

Tabla 4. Coeficientes de correlación entre los factores parciales

L	R	E	S
1.367	1.128	0.850	0.904

En la figura 6 se observa que la mayoría de los vectores que representan la variable de estudio (L) ilustran un ángulo con un comportamiento estable en los dos entornos. En relación al plano de los individuos, la figura 7 describe la trayectoria de cada una de las dimensiones vinculadas al factor de liderazgo respecto a cada enfoque de dirección, mismos que se encuentran proyectados en los dos primeros ejes factoriales. A este respecto se infiere que las dimensiones (1, 2, 4 y 5) describen los siguientes rasgos: los participantes argumentaron que el proyecto les permitió ser un referente de motivación para sus compañeros, consolidar su participación activa en las diferentes fases, presentar ideas de forma clara y articulada, finalmente es posible deducir que la estructura del proyecto les permitió demostrar sus destrezas de liderazgo ante situaciones difíciles.

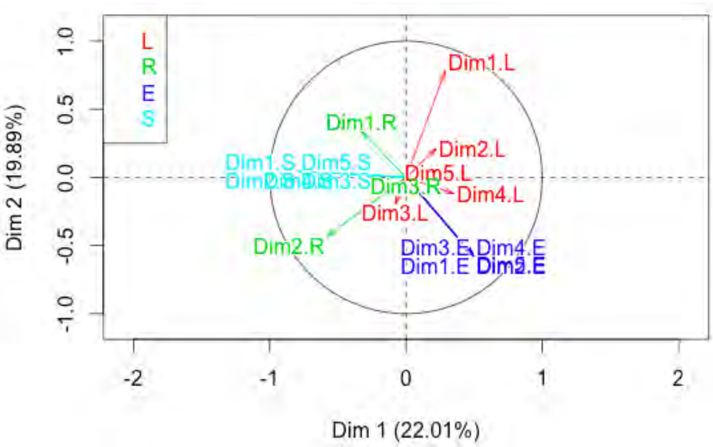

Figura 6. Proyección de las variables sobre los dos primeros ejes factoriales

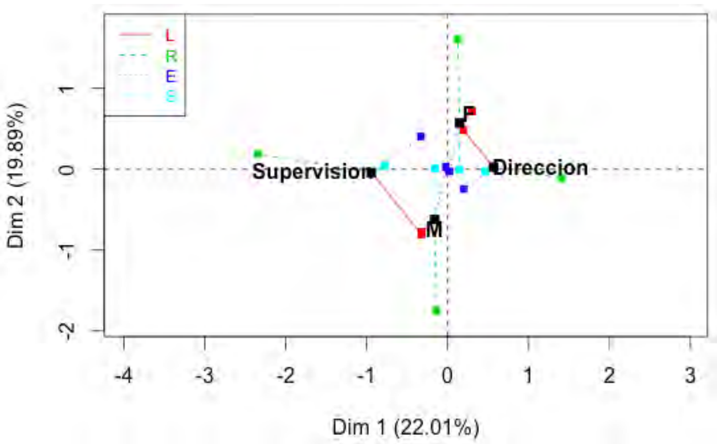

Figura 7. Grupos de variables de análisis

En síntesis, podemos concluir que las representaciones de los dos grupos de análisis sobre los dos primeros ejes globales recogen una realidad común para las variables de estudio. Los dos factores globales que fueron extraídos para el análisis están igualmente afectados por los dos enfoques vinculados al Rol durante las etapas de implementación del programa de mejora continua (véase Figura 8). Además, los valores próximos a la unidad explican una dirección de inercia importante para cada uno de los roles y su impacto en las actividades de Dirección y Supervisión. También es posible explicar la trascendencia del segundo eje global, pero su relación es en menor proporción.

Finalmente, los comportamientos de las variables latentes se explican en la proyección global de los planos principales. Hemos incorporado y desagregado al estudio las variables respuesta tales como el (CE) y (E) y la relación por ejemplo con la experiencia de los participantes en proyectos previos. A partir de los resultados representados en la Figura 6 se desprende de que para el 8% de los participantes que expresaron que la actividad no les resultó estimulante, tampoco cumplieron sus expectativas, se deduce que hasta el momento del estudio no habían tenido experiencia en actividades similares o en su caso muy poca experiencia. En contraste, con aquellos que cumplieron sus objetivos (92%) y el proyecto les resultó estimulante.

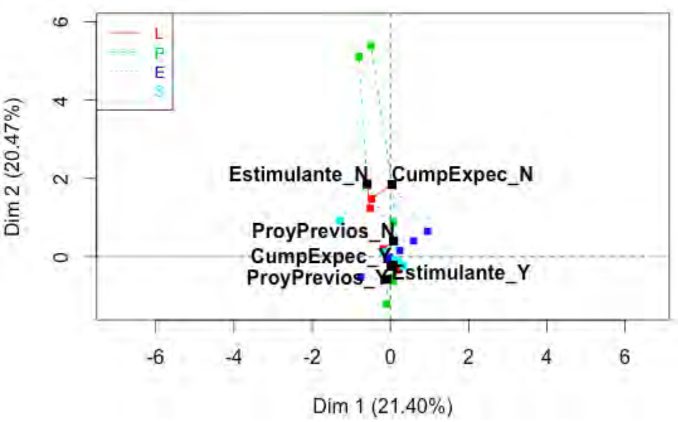

Figura 8. Proyección de las variables sobre los planos principales

5 Conclusiones

Este procedimiento de combinación de técnicas factoriales nos permitió el tratamiento simultáneo desde un punto de vista descriptivo y comparativo de individuos en los que se ha medido la misma información a través de variables nominales. La naturaleza exploratoria de la técnica tuvo la ventaja de que los datos, expresan de forma factorial la relevancia de los mismos para cada grupo de individuos, dotando al estudio importancia relativa y global. La metodología ha proporcionado indicadores y gráficos que midieron la similaridad entre los perfiles de los grupos de estudio respecto a las variables dependientes e independientes vinculadas al perfil de los encuestados. Futuras investigaciones nos orientan a explorar nuevos hallazgos incorporando al estudio factores alternos como: el compromiso, la responsabilidad e iniciativa, así como extender este estudio hacia los impactos de estos mismos factores en las prácticas profesionales.

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Kit Based On Xbee and Arduino Type Micro Controllers for Support in Skills Development on Programming, Electronics and Automation in Decentralized Offer Programs

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Abstract

For higher education institutions in Colombia to meet the needs of tertiary education throughout the country (Decentralization) is almost impossible, especially in rural areas and in urban areas away from capitals. While efforts have been made to close these gaps, they continue to exist.

Generally with the decentralized programs it takes academic offer referring to agricultural areas; there are usually no courses that have technology as a discipline, even though they are relevant to the region. These careers regularly require the use of laboratories and workshops as a pedagogical and didactic tool for the achievement of specific competences.

The Pascual Bravo University Institution has been making efforts to reach different regions of the city, the department and the country, thus contributing to the decentralization of tertiary education in Colombia, showing its 35-year trajectory in the provision of programs in. distance modality and the 7 Programs that are currently in operation to cover decentralized areas, all belonging to the field of technological knowledge, providing the space of workshops and laboratories, thanks to the use of a mobile laboratory that allows the connection of hydraulic, pneumatic and electric, in addition, different kits or equipment of easy transport that complement the necessary resources for the offered programs.

One of these equipment transported to the rural areas and urban areas away from the capitals by means of the mobile laboratory is the one based on micro controllers Arduino and Xbee, equipment that allows the integration and practice of concepts of programming, communications and electronics, besides helping in the development of soft skills such as teamwork and time management given to their use in the development of Mechatronics and automation projects.

Keywords: Tertiary education, decentralization of education, laboratories, Arduino.

Equipo Basado en Micro Controladores Arduino y Xbee para Uso en Apoyo al Desarrollo de Competencias en Programación, Electrónica y Automatización en Programas de Oferta Descentralizada.

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Resumen

Para las instituciones de educación superior en Colombia cubrir las necesidades de educación terciaria en todo el territorio nacional (Descentralización) es casi imposible, especialmente en zonas rurales y en zonas urbanas alejadas de las capitales. Si bien se han venido realizando esfuerzos para cerrar estas brechas, estas siguen existiendo.

Generalmente con los programas descentralizados se lleva oferta académica referente a áreas agropecuarias. Habitualmente no se imparten carreras que tengan la tecnología como disciplina, aun cuando son de pertinencia para la región. Estas carreras requieren regularmente el uso de laboratorios y talleres como herramienta pedagógica y didáctica para el logro de competencias específicas en el área.

La Institución Universitaria Pascual Bravo ha venido realizando esfuerzos para llegar a diferentes regiones de la ciudad, el departamento y el país, contribuyendo así a la descentralización de la educación terciaria en Colombia, muestra de ello es su trayectoria de 35 años en la oferta de programas modalidad distancia y los 7 Programas que tiene actualmente en funcionamiento para cubrir zonas descentralizadas, todos ellos pertenecientes al campo de conocimiento tecnológico, proporcionando el espacio de talleres y laboratorios, gracias al uso de un laboratorio móvil que permite la conexión de sistemas hidráulicos, neumáticos y eléctricos, además, diferentes kits o equipos de fácil transporte que complementan los recursos necesarios para los programas ofertados.

Uno de los equipos transportados a las zonas rurales y zonas urbanas alejadas de las capitales por medio del laboratorio móvil es el basado en micro controladores Arduino y Xbee, equipo que permite la integración y practica de conceptos de programación, comunicaciones y electrónica, además de ayudar en el desarrollo de competencias blandas como el trabajo en equipo y el manejo del tiempo dado a su utilización en el desarrollo de proyectos de Mecatrónica y automatización.

Palabras Clave: Educación terciaria, descentralización de la educación, laboratorios, Arduino.

1 La ruralidad en Colombia

El gobierno Colombiano define un territorio rural como “un espacio histórico y social, delimitado geográficamente con cuatro componentes básicos: un territorio con actividades económicas diversas, interrelacionadas; una población principalmente ligada al uso y manejo de los recursos naturales, unos asentamientos con una red de relaciones entre sí y con el exterior y unas instituciones, gubernamentales y no gubernamentales, que interactúan entre sí” (Ministerio de Educación Nacional, 2012). El país ha caracterizado a la población rural con el criterio estadístico de resto, es decir, aquella ubicada por fuera de las cabeceras de los municipios, sean estos ciudades grandes, intermedias o pequeños pueblos, y representan a 2015 11.302.519 habitantes, lo que equivale al 23,7% de la población total (Ministerio de Educación Nacional, 2015), esta distribución puede verse en la Figura 1. La población rural está compuesta en su base social por los campesinos, incluyendo en este término pequeños productores, indígenas, afrocolombianos y campesinos sin tierra, según (Ministerio de Educación Nacional, 2015).

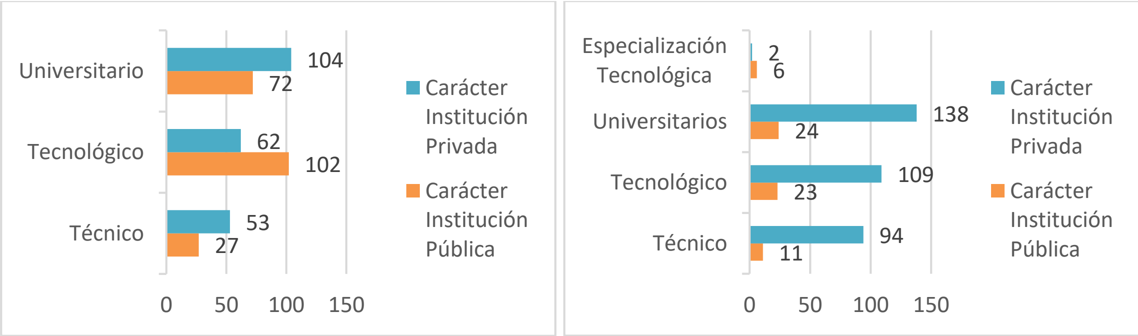
Figura 47. Población por categorías de ruralidad (Departamento Nacional de Planeación & Mision para la transformación del campo, 2015)

Las poblaciones campesinas (indígenas, afrocolombianas y rural mestiza) se diferencian por su ubicación geográfica y su contexto productivo territorial. Unas habitan zonas donde predominan la pequeña propiedad o formas de acceso a la tierra que no significan apropiación individual sino posesión (régimen de resguardos o territorios comunales). La mayoría, explotan pequeñas unidades productivas, combinan cultivos permanentes de productos de exportación (café, especialmente), con los cultivos de productos agrícolas y ganadería en pequeña escala, orientados principalmente al pequeño comercio local o regional(Ministerio de Educación Nacional, 2015).

Por otra parte en Colombia el desarrollo del país ha sido diferenciado, con un sesgo favorable a la población urbana en detrimento de la rural (Ministerio de Educación Nacional, 2015), razón por la cual se han consolidado brechas en términos de indicadores de calidad de vida en lo social (acceso a educación, agua potable, protección social, salud, vivienda, seguridad, recreación y cultura) y en el campo económico (acceso a tierras, infraestructura vial, crédito, adecuación de tierras mediante el riego, ciencia y tecnología para la innovación productiva). Dichas brechas señalan que los pobladores rurales han accedido en menor medida a los bienes públicos, tanto sociales como productivos, que puede proporcionar el Estado obteniendo como resultado una situación de exclusión la cual se manifiesta en un índice de pobreza multidimensional, de 45,9% en zona rural y 18,5% en cabeceras municipales(Ministerio de Educación Nacional, 2015).

1.1 El problema de la oferta descentralizada de educación en el País

En el ámbito educativo el campo colombiano, durante más de cuatro décadas, ha sido escenario de violencia, pobreza y reformas fallidas o inconclusas (Arango Carrero & González Rodríguez, 2016) el Ministerio de Educación Nacional, 2015 afirma que la información disponible muestra que el sistema educativo nacional todavía no tiene la capacidad de garantizar a todas las personas que viven en las zonas rurales el goce pleno del derecho a la educación lo que incide negativamente en el bienestar de la población en lo concerniente al acceso a los bienes públicos sociales y, por tanto, en el grado de inclusión del que disfrutan el resto de los colombianos. En lo referente a la educación terciaria, la cobertura es mínima y la oferta para las zonas rurales y de gran dispersión poblacional es limitada (Ver figura 2). En 2013, en la zona urbana el 29,7% de los jóvenes mayores de 17 años obtenía un título en educación superior, en la zona rural, sólo lo hacía el 5,1%.



a b

Figura 2. a) Oferta de programas de pregrado Distancia Tradicional en Colombia. b) Oferta de programas de pregrado Virtual en Colombia (Sistema Nacional de Información de la Educación Superior, 2017)

Según el Departamento Nacional de Planeación & Mision para la transformación del campo, 2015 en materia de educación técnica, tecnológica y profesional, el país debe profundizar en las iniciativas que facilitan el acceso de la población rural como: la oferta de cursos de formación presencial; la articulación de la educación media a la técnica ,además, del desarrollo de programas virtuales y a distancia de formación; la oferta de programas de los Centros Regionales de Educación Superior; la construcción de nuevas sedes territoriales de las universidades públicas; y los apoyos de sostenimiento a la población vulnerable que accede a programas de educación superior y que requieren de su traslado a otro lugar de residencia. Igualmente se debe garantizar una educación pertinente y de calidad que facilite la inclusión productiva e incentive la creatividad y la innovación con la cual se asegure la competitividad en las actividades productivas rurales.

Ministerio de Educación Nacional, 2015 advierte que diversos análisis reclaman fortalecer la formación de personas con alta y especializada formación técnica y profesional en relación con la actividad agropecuaria y las nuevas actividades del sector rural, esto encaminado a elevar la productividad y poner al alcance del país los desarrollos más avanzados, lo que está estrechamente relacionado con el capital humano. En lo referente al capital social se busca el aprendizaje o afianzamiento de valores, saberes y actitudes que permitan la convivencia, la resolución negociada de conflictos, el trabajo en equipo, la responsabilidad en el trabajo asociativo, el respeto por los derechos de los demás y por la conservación del ambiente y los recursos para la vida en común, todos ellos necesarios en la Colombia rural. La formación de capital humano y social es entonces una gran tarea para el sector educativo. La experiencia mundial muestra que la capacidad técnica y de asociación es una condición indispensable para que los pequeños productores rurales afronten con éxito asuntos como la industrialización y, las relaciones con las grandes empresas agroindustriales y el Estado, la financiación, la asistencia técnica y la comercialización (Ministerio de Educación Nacional, 2015).

Todo lo anterior es esencial para garantizar que la educación sea un verdadero instrumento de movilidad social, tanto para los jóvenes que deciden quedarse en el campo, como para los que migran hacia las ciudades (Departamento Nacional de Planeación & Mision para la transformación del campo, 2015), lo que representa un reto tanto para el gobierno nacional, como para los departamentales y municipales, a su vez que la representación demográfica de la población rural, su importancia económica, pero sobre todo el momento político de la sociedad colombiana (Ministerio de Educación Nacional, 2015).

2 Equipo Basado en Micro Controladores Arduino y Xbee para Uso y Apoyo pedagógico.

2.1 La Oferta descentralizada en la IU Pascual Bravo

En el país la mayoría de oferta educativa a zonas rurales está relacionada con el agro. Se debe tener en cuenta que la tecnología permite resolver problemas y satisfacer necesidades individuales y sociales,lo que permite transformar el entorno y la naturaleza mediante la utilización racional, crítica y creativa de recursos y conocimientos (Arango Carrero & González Rodríguez, 2016), otro aspecto importante es que la educación en tecnología posibilita desarrollar competencias en el manejo de fuentes de información y el desarrollo de capacidades para la presentación de propuestas de solución de problemas vinculados a necesidades concretas (Arango Carrero & González Rodríguez, 2016). Por otra parte el desarrollo en el campo del sector de los servicios y el surgimiento de actividades no agropecuarias aportan al habitante rural importantes ingresos (Lozano Flórez, 2012), asimismo, existe la posibilidad de la unión de conocimientos interdisciplinares entre el agro y la tecnología para el desarrollo de ciencia, tecnología e innovación en el campo, donde para la (Misión para la Transformación del Campo, 2015) uno de los principales obstáculos es la falta de recurso humano.

Como aporte a la solución de esta problemática la Institución Universitaria Pascual Bravo (IU Pascual Bravo) inicio su participación en la Educación Superior Abierta y a Distancia desde el año 1982 cuando se acogió al Decreto 2412 que reglamentó esta modalidad en el país. (IU Pascual Bravo, 2017), actualmente cuenta con 5 programas en la modalidad distancia tradicional y 2 en modalidad virtual, los cuales son ofrecidos en 17 municipios del departamento de Antioquia y en la ciudad de Santa Marta en el departamento del Magdalena, todos ellos programas tecnológicos de oferta descentralizada.

2.2 Laboratorio Móvil

El acceso a la educación superior y especialmente a laboratorios de prácticas es indispensable si se pretende reducir esta brecha entre la educación centralizada y la descentralizada, además, los Indicadores Agrícolas de ciencia y tecnología indican que el país ha mantenido un promedio de inversión pública de 0,5% del PIB sectorial en actividades de ciencia y tecnología agropecuarias en los últimos años. Este nivel es bajo en comparación con otros países latinoamericanos (Misión para la Transformación del Campo, 2015).

La (Misión para la Transformación del Campo, 2015) asocia la baja inversión sectorial en investigación y desarrollo a la baja oferta de investigación básica y adaptativa, de paquetes tecnológicos adecuados a condiciones locales, entre otros aspectos. Lo anterior estrechamente relacionado con la formación de capital humano en carreras tecnológicas, donde se hace indispensable la educación experiencial y práctica así como la consolidación de saberes en ambientes de aprendizaje como los laboratorios.

La IU Pascual Bravo en busca de formas de llevar educación con calidad a las regiones ha hecho uso de un laboratorio móvil (Ver Figura 3) el cual permite la conexión de sistemas hidráulicos, neumáticos y eléctricos, al mismo tiempo que el transporte de diferentes kits o equipos que complementan los recursos necesarios para los programas ofertados; el laboratorio móvil también cuenta una planta de energía eléctrica.

Figura 3. Laboratorio Móvil IU Pascual Bravo

2.3 Equipo Basado en Micro Controladores Arduino y Xbee

Como se mencionó el laboratorio móvil permite transportar y conectar diferentes kits o equipos que complementan los recursos necesarios para los programas ofertados en regionalización, es decir, en oferta descentralizada, entre ellos se encuentra el kit de Arduino y Xbee (Figura 4), que permite realizar prácticas para el desarrollo de competencias de programación, comunicaciones, electrónica, más proyectos de automatización, mecatrónica.

El kit de Arduino y Xbee contiene elementos como fuentes reguladas CA 100-240V a DC 12 V 5A 60W, reguladores 12V a 5V 3A 15W, protoboard 830 puntos MB 102, cables conectores para protoboard, pantalla LCD 16 x 2, conectores hembra tipo banana, accionamientos tipo start NA, accionamientos tipo stop NC,tarjetas Arduino Mega 2560 R3, módulo Relé 8 canales con opto Arduino, módulos X-Bee serie 2 con antena- cable B24-Z7WIT-004, módulo Bluetooth + cable USB, shields Bluetooth, adaptador X-Bee USB, shields Ethernet R3, sensor ultrasonido HC-SR04, sensor de distancia x infrarrojos 0A41SK, sensor de presión FSR402, sensor termopar tipo K.

Todos los proyectos y prácticas realizados con el kit están encaminados a solucionar problemas en actividades como la agricultura, industria pequeña y mediana, comercio, servicios, ganadería, pesca, minería, turismo y extracción de recursos naturales, los cuales pueden ser logrados con el uso de uno o varios elementos contenidos en el kit. Entre los proyectos realizados están invernaderos, proyectos domóticos, programación de secuencias de bombas, programación de robots, brazos robóticos como es el caso del mostrado en (Lemmel-Vélez & Valencia-Hernandez, 2017), sistemas de riego, automatización de puertas, comunicación inalámbrica, entre otros.

Figura 4. kit de Arduino y Xbee

3 Resultados

Como forma de validación del kit y como herramienta para valorar las competencias alcanzadas tanto técnicas como blandas se diseñó una encuesta de 14 preguntas, la cual fue contestada por 18 estudiantes, obteniendo como resultados los mostrados en las figuras 5-15, las preguntas de la 1 a la 11 están basadas en la escala de Lickert mostrada en la tabla 1, Para las preguntas de la 12 a la 14 la respuesta es sí o no.

Tabla 26. Escala de Lickert.

Concepto	Ponderación
Nunca	1
Muy pocas veces	2
Algunas veces	3
Casi siempre	4
Siempre	5

1. Considera que el uso de Arduino y/o Xbee permite la integración y práctica de conceptos de programación.

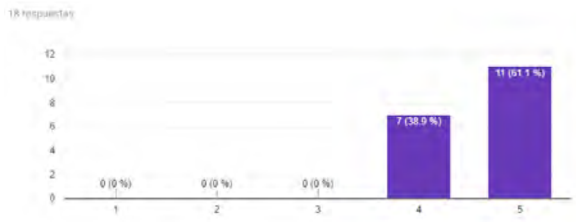


Figura 5. Respuestas pregunta uno

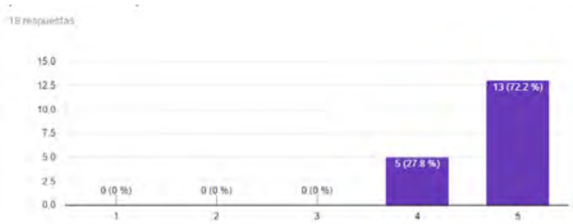


Figura 6. Respuestas pregunta dos

2. Considera que el uso de Arduino y/o Xbee permite la integración y práctica de conceptos de comunicaciones.

3. Considera que el uso de Arduino y/o Xbee permite la integración y práctica de conceptos de electrónica.

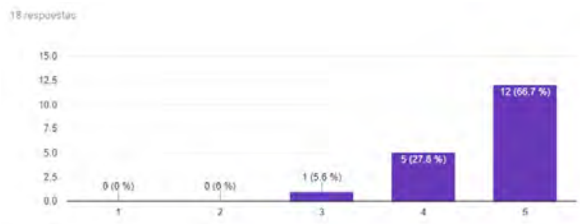


Figura 7. Respuestas pregunta tres

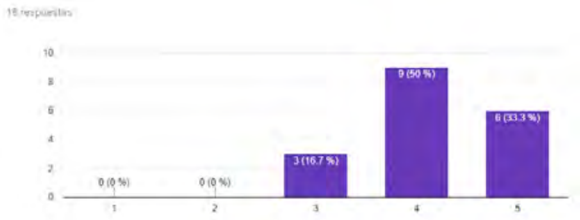


Figura 8. Respuestas pregunta cuatro

4. Considera que el uso de Arduino y/o Xbee permite la integración y práctica de conceptos de circuitos eléctricos.

5. Considera que el uso de Arduino y/o Xbee facilita el desarrollo de proyectos de automatización y/o mecatrónica

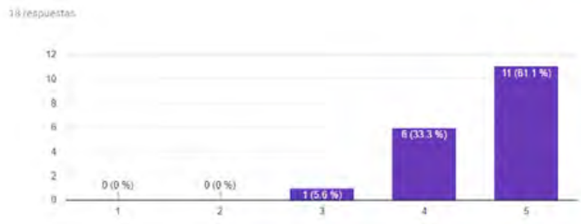


Figura 9. Respuestas pregunta cinco

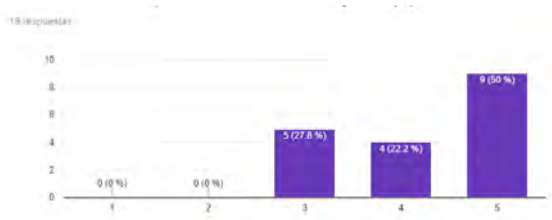


Figura 10. Respuestas pregunta seis

6. Considera que el desarrollo de prácticas y proyectos que incorporan los módulos Arduino y/o Xbee incentivan el trabajo en equipo.

7. Considera que el desarrollo de prácticas y proyectos que incorporan los módulos Arduino y/o Xbee propician la administración adecuada del tiempo

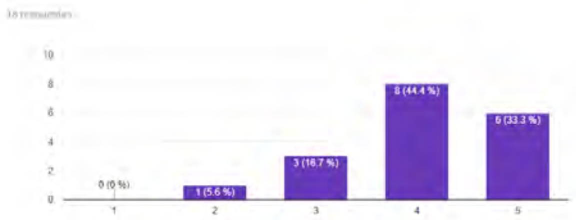


Figura 11. Respuestas pregunta siete

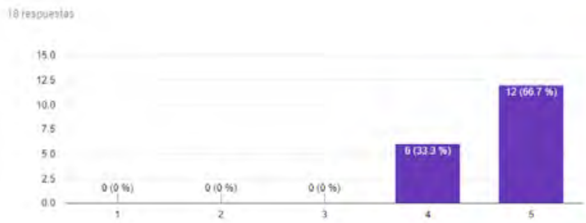


Figura 12. Respuestas pregunta ocho

8. Considera que el uso de Arduino y/o Xbee en el desarrollo de proyectos de automatización y/o mecatrónica ayudan al desarrollo de la creatividad.

9. Considera que las prácticas con Arduino y/o Xbee poseen el suficiente rigor teórico y científico.

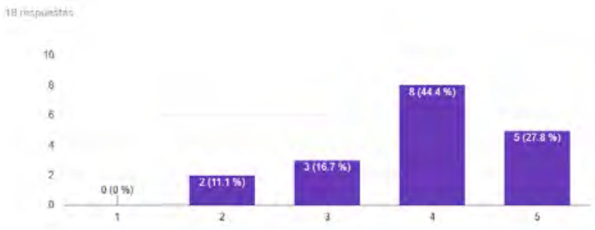


Figura 13. Respuestas pregunta nueve

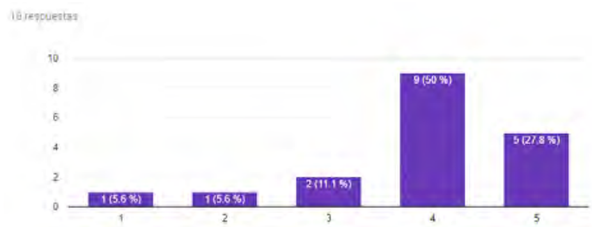


Figura 14. Respuestas pregunta diez

10. Considera que el trabajo con Arduino y/o Xbee ayuda a mejorar las relaciones interpersonales con los compañeros, el docente y los monitores

11. Considera que el trabajo con Arduino y/o Xbee permite incentivar la toma de decisiones

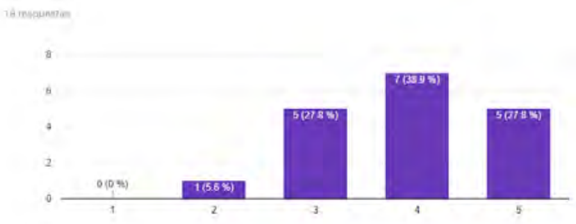


Figura 15. Respuestas pregunta once

12. Considera que la tecnología de Arduino y las comunicaciones con Xbee permiten realizar proyectos integrados con la agroindustria.

13. Considera que los conocimientos adquiridos con el uso de Arduino y/o Xbee le serán de utilidad en el futuro.

14. Considera que los conocimientos adquiridos con el uso de Arduino y/o Xbee tienen relación con la carrera que cursa.

Como puede apreciarse el 61% considera que el uso de Arduino y Xbee permite la integración y practica de conceptos de programación, el 72.25% piensa que se realizan prácticas y talleres en comunicaciones, el 66.7% relaciona el trabajo con el kit siempre con conceptos de electrónica, mientras que el 5.6% considera que solo lo hace algunas veces, respecto a las competencias con circuitos eléctricos el 50% considera que casi siempre se practica y en cuanto al desarrollo de proyectos de automatización y mecatrónica el 61.1% encuentra correspondencia con el kit usado.

Respecto a competencias blandas solo el 50% concibe que siempre se incentiva el trabajo en equipo, en relación con la administración adecuada del tiempo el 5.6% considera que pocas veces se propicia y el 33.3% cree que se desarrolla esta competencia. En cuanto a la creatividad, el 66.7% considera que siempre se desarrolla con ayuda de los proyectos de automatización y mecatrónica, cuando se pregunta por el rigor científico el 44.4% piensa que es suficiente.

Para las relaciones interpersonales, el 50% considera que las prácticas de laboratorio siempre permiten mejorarlas, y el 38.9% entiende que casi siempre se incentiva la toma de decisiones. La respuesta a la realización de proyectos de agroindustria, la utilidad de los conocimientos adquiridos para el futuro y la relación de los laboratorios con el programa fue para todos los casos sí, es decir, el 100% de las respuestas fueron afirmativas.

Teniendo en cuanto los resultados de la encuesta se evidencia que, en general, las prácticas de laboratorio usando el kit de Arduino y Xbee están bien enfocadas al entorno y a la población a la que se ofrecen, permitiendo así el apoyo a la formación tecnológica en programas de oferta descentralizada. Sin embargo hay aspectos como la competencia en electrónica, la administración del tiempo, el rigor científico, las relaciones interpersonales y la toma de decisiones que deben ser replanteados en los proyectos, para fomentar aún más el alcance de dichas competencias.

4 Conclusión

El uso del Equipo Basado en Micro Controladores Arduino y Xbee permite el desarrollo de competencias en programación, electrónica y automatización en programas de oferta descentralizada, al igual que el desarrollo de algunas competencias blandas como trabajo en equipo. Asimismo permite la integración de conceptos tecnológicos con el sector agropecuario, en aras de desarrollar proyectos que propicien actividades de ciencia y tecnología agropecuarias.

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Proposal of an active methodology for large groups and multiple contents: A pilot experience of the University of Brasilia through bibliometrics.

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Abstract

Usually in engineering courses they have subjects that become real challenges due to the presence of a large number of students and high failure rates. The subject of Industrial Organization (OI) at the University of Brasilia, is responsible for training students of eight different Engineering (8ID) in the content relating to Production Engineering; Environmental, Civil, Mechanics, Control and Automation, Electrical, Networks, Computing and Chemistry). However, subjects with these characteristics are usually taught through a traditional methodology. OI is a subject that must obey three axes: Engineering of Production, Sustainability and the contents referring to each basic area of the student, being able to vary between the 8IDs, in a context of class with 240 students. In an attempt to propose an alternative to the traditional classes, an initiative was carried out that could meet the requirements related to the three axes of the content at the same time and that provided a new privilege to the classes. The answer to this problem was obtained through bibliometrics, which offers possibilities of composing multiple contents. Thus, the objective of this study was to present an active methodology of learning based on bibliometrics. The methodology used to perform the bibliometric content search was the Theory of the Consolidated Analytic Goal Approach (TEMAC). For the delivery of the results an online form was developed (https://www.onlinepesquisa.com/s/2dfbb71) which, once filled, automatically integrates the content into a report. This way we used the Production Engineering and sustainability as search terms and the Engineering area from which the student is the delimiter filter. The results allow not only to comply with the contents, but also to present an active methodology solution to work with large groups. Since August 2017 the EPR-UnB has used the initiative of the use of bibliometrics. The results achieved add up to 70 articles completed by the students.

Keywords: Active Methodologies, Bibliometrics, Multiple Content

Propuesta de metodología activa para grandes grupos y múltiples contenidos: Una experiencia piloto de la Universidad de Brasilia por medio de la bibliometría.

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Resumen

Usualmente en los cursos de Ingeniería se tienen asignaturas que se tornan verdaderos desafíos por presentarse un gran número de estudiantes y altos índices de reprobación. La asignatura de Organización Industrial (OI) en la Universidad de Brasilia, es responsable de formar estudiantes de ocho Ingenierías diversas (8ID) en los contenidos referentes a la Ingeniería de Producción; Ambiental, Civil, Mecánica, Control y Automación, Eléctrica, Redes, Computación y Química. Sin embargo, asignaturas con estas características suelen ser impartidas por medio de una metodología tradicional. OI es una asignatura que debe abarcar tres ejes: Ingeniería de Producción, Sostenibilidad y los contenidos referentes a cada área básica del estudiante, pudendo variar entre las 8ID, en un contexto de clase con 240 estudiantes. En un intento de proponer una alternativa a las clases tradicionales, fue realizada una iniciativa que pudiera cumplir de manera paralela con los requisitos relacionados con los tres ejes del contenido y que proporcione un nuevo beneficio a las clases. La respuesta a este problema se obtuvo a través de la bibliometría, que ofrece posibilidades de componer contenidos múltiples. Así, el objetivo de este estudio fue presentar una metodología activa de aprendizaje basada en la bibliometría. La metodología utilizada para realizar la búsqueda de contenido bibliométrico fue la Teoría del Enfoque Meta Analítico Consolidado (TEMAC). Para la entrega de los resultados fue desarrollado un formulario online (https://www.onlinepesquisa.com/s/2dfbb71) que una vez llenado incorpora el contenido automáticamente en un informe. Así se utilizó la Ingeniería de Producción y sostenibilidad como términos de la búsqueda y el área de la Ingeniería de donde procede el estudiante que es el filtro delimitador. Los resultados permiten no solo cumplir los contenidos, sino también presentar una solución de metodología activa para trabajar con grandes grupos. Desde agosto de 2017 la EPR-UnB utiliza la iniciativa del uso de la bibliometria. Los resultados alcanzados suman cerca de 70 artículos terminados por los estudiantes.

Palabras-Clave: Metodologías Activas, Bibliometría, Múltiples contenidos

1 Introducción

En Brasil, algunas asignaturas en los cursos de Ingeniería suelen tener un gran número de estudiantes. Muchas de estas asignaturas son de responsabilidad de un curso específico, por ejemplo Organización Industrial, ofertada por la carrera de Ingeniería de la Producción a las demás Ingenierías.

En el ámbito de la formación académica, constatamos que la correcta comprensión de la Ingeniería de la Producción por medio de la asignatura Organización Industrial (OI), constituye uno de los más grandes desafíos para los estudiantes de los demás cursos. Especialmente conciliar el interés del estudiante en relación a una asignatura que no es parte del "*corazón del currículo*" de su área de conocimiento.

En la Universidad de Brasilia el Curso de Ingeniería de la Producción (EPR-UnB) trabaja desde el año 2011 con metodologías activas mediante *Project Based Learning*. Sin embargo, esta experiencia aplicada a las demás Ingenierías en la asignatura de Organización Industrial siempre se desarrolló con un obstáculo muy grande: el número de estudiantes en clase (en el segundo semestre de 2017 la clase de OI contaba con 240 estudiantes). En la literatura existen ejemplos exitosos de metodologías activas aplicadas a clases con gran número de estudiantes, aumentando el grado de aprobación de 50% a 95% (Fragelli & Fragelli, 2017).

Sin embargo, cuando se suman variables del actual contexto de la educación como la inclusión, diversidad, nuevas tecnologías, aplicación, investigación, múltiples contenidos y libertad de conocimiento para el estudiante, el proceso se torna complejo. Y está complejidad se potencializa cuando el contenido pasa por los tres ejes (uno sobre el contenido de la asignatura, otro del contenido de la Ingeniería a la cual el estudiante pertenece y un tercer eje de sostenibilidad, que es un tema creciente en las Ingenierías). Proporcionar a este estudiante de autonomía para aprender es garantizar que el organice el contenido de acuerdo con sus necesidades. Aunque muchos profesores estén siempre buscando nuevas maneras de responder las interrogantes de la educación, pocos son lo que se deciden por el uso de los recursos que poseen. Usualmente acaban por utilizar factores extra clase, dando la sensación de que el aula es en verdad un castigo para el estudiante.

En un intento de ofrecer una opción para garantizar que los desafíos sean superados, en el segundo semestre del 2017, la EPR-UnB, en la asignatura de OI ha resuelto crear un método personal de metodología activa, el BBL (*Bibliometric Based Learning)*, que consiste en el uso de la bibliometría en el aprendizaje.

La bibliometría es una técnica cuantitativa y estadística de medición de los índices de producción del conocimiento científico que mapea la ciencia, sus descubrimientos y relaciones (Fonseca, 1986). Por medio de su uso se puede tener acceso al conocimiento más reciente. Su uso siempre fue conectado a la investigación científica de impacto, garantizando el uso de referencias de calidad. Así el objetivo de este estudio fue presentar una metodología activa de aprendizaje basada en la bibliometría.

Para alcanzar este objetivo se utiliza la Teoría del Enfoque Meta Analítico Consolidado-TEMAC.

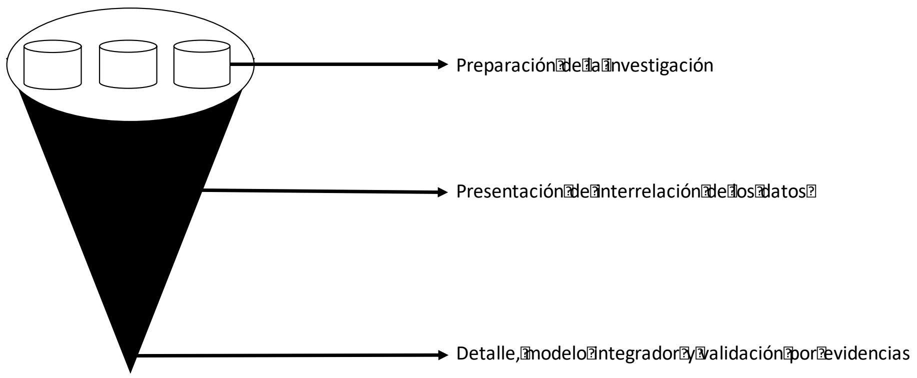
2 Fundamentación Teórica

2.1 Teoría del Enfoque Meta Analítico Consolidado-TEMAC

Muchos autores han usado la bibliometria como método de investigación (Pritchar, 1969; Garfield, 1972; Mugnaini et al., 2004; Hirsch, 2005; Bornmann e Daniel, 2008; Abramo; D'angelo e Di Costa Ferreira, 2009; Mariano; Cruz & Gaitán, 2011; Ramírez, *et al.*, 2014; Calazans *et al.,* 2015; Mariano et al. 2011a, 2011b, 2012). Sin embargo, su aplicación en la enseñanza es aun escasa, ya que no fueron encontrados artículos de su aplicación en metodologías activas.

El enfoque meta analítico es una derivación del método meta análisis que surgió con el trabajo de Arenas, García & Espasandín (2001), pero se consolidó como técnica en los trabajos de García & Ramírez (2004, 2005). En 2011, Mariano, García & Arenas hicieron una actualización en siete etapas y desde entonces muchas otras versiones fueran realizadas. En 2017 Mariano & Rocha, han creado una versión consolidada llamada Teoría del Enfoque Meta Analítico Consolidado-TEMAC, que posee tres etapas como se muestra en la figura 1.

Figura 1. Modelo TEMAC. Fuente: Mariano & Rocha.



Etapa 1. Preparación de la investigación Objetiva, donde se debe responder inicialmente cuatro preguntas:

- ¿Cuál es el descriptor, *string* o palabra-clave de la investigación?
- ¿Cuál es el campo espacio-tiempo de la investigación?
- ¿Cuáles son las bases de datos que serán utilizadas?
- ¿Cuáles son las áreas del conocimiento que serán utilizadas?

Etapa 2. Presentación e interrelación de los datos. Encontrar por medio de la técnica: a. análisis de las revistas más relevantes; b. análisis de las revistas que más publican sobre el tema; c. evolución del tema año a año, d. documentos más citados; e. autores que más publican v.*s.* Autores que más fueron citados; f. países que más publicaron; g. conferencias que más contribuyeron; h. universidades que más publicaron, i. agencias que más financiaron la investigación; j. áreas que más publicaron e l. frecuencia de palabras claves.

Etapa 3. Detalle, modelo integrador y validación por evidencias. Después de haber registrado los primeros datos, son necesarios realizar análisis más profundos para conocer las principales líneas de investigación, escuelas, contribuciones. Con esta información es posible crear modelos integradores y validación por evidencias.

El artículo *"Revisão da Literatura: Apresentação de uma Abordagem Integradora."* (Mariano& Rocha, 2017), explica cada etapa con su aplicación.

3 Método

Este estudio es exploratorio con enfoque cualitativo por medio de estudio de caso. El campo de estudio fue la Universidad de Brasilia y el objeto de estudio fue la asignatura de Organización Industrial. Este estudio presenta los procedimientos y resultados preliminares.

Fue realizado el BBL como método de la asignatura en agosto de 2017 y con previsión de terminar en Diciembre de 2017. Las clases fueran divididas en dos partes. 2 horas para presentación del contenido de la Ingeniería de la Producción y 2 horas de integración con los ejes de cada Ingeniería y sostenibilidad.

Los resultados son una parte de las etapas de este proyecto piloto, ampliándose más información en el apartado 4

4 Resultados y Análisis

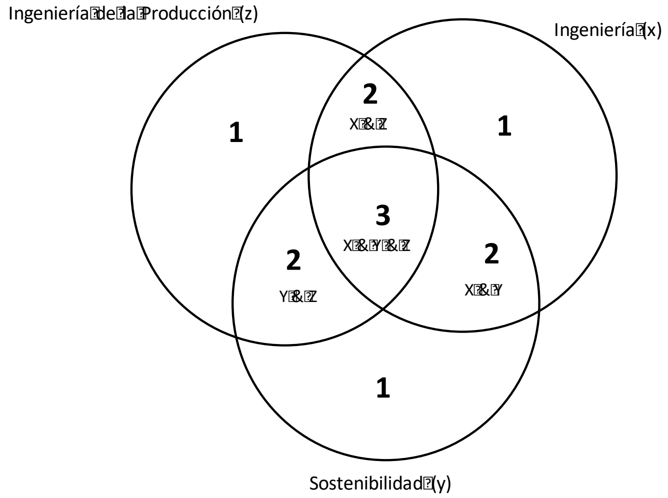
4.1 Diseño de la asignatura mediante la Bibliometría

Inicialmente se estableció los tres ejes de la asignatura como se muestran en la figura 2 (Ingeniería de la Producción, Ingenierías y Sostenibilidad). Para cada Ingeniería fue levantada las áreas del Examen Nacional de Desempeño de los Estudiantes (ENADE). Cuanto más ricas sean las sub áreas, más posibilidades se tendrá para lograr resultados; el segundo eje es la Ingeniería de la Producción, obtenida de las áreas de la Asociación Brasileña de Ingeniería de la Producción – Abepro; por último, el tercer eje de sostenibilidad (Económica, Social y ambiental).

La primera etapa de la clase, el profesor explica principios básicos de uno de los temas de la Ingeniería de la Producción. En él según momento de la clase los estudiantes realizan su búsqueda en la base de datos y rellenan una encuesta *on-line* (https://www.onlinepesquisa.com/s/2dfbb71) para integrar los datos en los ejes.

Cada análisis realizado proporciona al estudiante la posibilidad de conocer autores y trabajos que son a favor o en contra de las principales ideas discutidas anteriormente en clase, dando al estudiante la posibilidad de elegir el camino a seguir, haciendo del contenido una decisión para el estudiante.

Figura 2. Ejes de la Asignatura



Fuente: propia

4.2 Medición del desempeño

Para medir el desempeño del estudiante en la asignatura será utilizado un enfoque constructivista de la nota, como se muestra en la figura 3.

Figura 3- Evaluación del estudiante

	Webqualis	*Scielo*	*Scopus*	*Web of Science*
1	0,00	0,05	0,07	0,10
2	0,10	0,30	0,50	1,00
3	1,00	2,00	4,00	**5,00**

Bonus Track

	2	**3**	**4**
Artículos con modelos	25%	40%	60%
Artículos de Review	40%	60%	80%
Artículos con Técnica Similar	50%	75%	100%

Fuente: propia

La evaluación empieza por la cantidad de artículos en la integración de los ejes. El estudiante que elige trabajar solo un eje recibe entre 0 y 0,10 por artículo dependiendo de la base de datos. Si usa dos bases de datos los valores cambian para las puntuaciones entre 0,10 y 1,0 y con 3 entre 1,0 y 5,0 puntos, la nota máxima en esta etapa. El estudiante que alcance los 5 puntos, puede ir a *bonus track* , con puntos diferenciados para artículos con modelos, Revisión bibliográfica y artículos con técnicas similares, variando de 25% a 100% de la nota de la primera parte de la evaluación, componiendo así la nota final.

Sin embargo, estos artículos son el final del proceso porque antes viene la aplicación del TEMAC y el registro de los resultados que confieren rigor al sistema. Los registros son realizados vía internet https://www.onlinepesquisa.com/s/2dfbb71 donde el estudiante complementa los datos. Cada registro al final integrará un artículo de revisión bibliográfica

4.3 Resultados parciales

Desde agosto de 2017 que la EPR-UnB utiliza la iniciativa de aplicar la bibliometría. Los resultados alcanzados suman cerca de 70 artículos terminados por los estudiantes. Otro resultado importante es delegar al estudiante el nivel de formación que pretenda, así como la línea metodológica que quiera seguir. Por ejemplo, en una búsqueda de un estudiante sobre "*Lean Construction*", el estudiante obtuvo como resultado dos enfoques, uno que apoya el uso y otro en contra del *Lean Construction*. Un grupo de autores explicaba que el *Lean Construction* es importante, cuando está bien hecho. Sin embargo, eso no es tarea de un Ingeniero y si de un gestor. El otro grupo era a favor del *Lean Construction.* Este artículo no busca discutir quien está en lo correcto o no, solamente se pretende dejar establecido que la línea a seguir depende exclusivamente del estudiante, disponiendo de una autonomía para su aprendizaje.

5 Conclusiones

El objetivo de este estudio fue presentar una metodología activa de aprendizaje basada en la bibliometría. Esta metodología fue presentada por medio del TEMAC. Aunque al principio los estudiantes estaban reacios al cambio, con el transcurso del avance de las clases fueron encontrando utilidad al método BBL, solamente en la asignatura de OI y no así en otras asignaturas.

Se espera que con estos resultados parciales el método se consolide y pueda tener aceptación en otras áreas del conocimiento, pues al usar la bibliometría el estudiante adquiere una experiencia con alto rigor por medio de la investigación, aportando favorablemente para su carrera universitaria.

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Use of project-based learning in real scenarios as a learning assessment tool

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Abstract

The work consisted in a qualitative research of exploratory type with a group of students of Industrial Logistic Engineering of the Faculty of Chemical Engineering of the Autonomous University of Yucatan, with the objective of knowing and analyzing the impact of the Project Based Learning methodology (PBL) carried out in real companies and the acquisition of new competences for their professional development. The results show that 100% of the students have developed at least one project in these circumstances and that 70% of them fully agree that the application of the project in a real company contributes to their professional growth on the other hand 63% said that the PBL can contribute to the development of personal skills and acquisition of new knowledge. Finally, 56% fully agree that the PBL learning method must be carried out in most of the subjects they attend throughout their university education. In conclusion due to the impact of this methodology in the training of students, more subjects must be adapted to this scheme, although the time to complete the project is one of the biggest obstacles students face.

Keywords: Project-based learning; Internship; Personal competences; Real life learning scenarios; Skills.

Utilización del aprendizaje basado en proyectos en escenarios reales como herramienta de evaluación del aprendizaje

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Abstract

El trabajo consistió en una investigación cualitativa de tipo exploratorio con un grupo de estudiantes de Ingeniería Industrial Logística de la Facultad de Ingeniería Química de la Universidad Autónoma de Yucatán, con el objetivo de conocer y analizar el impacto de la metodología de Aprendizaje Basado en Proyectos (PBL) llevado a cabo en empresas reales y la adquisición de nuevas competencias para su desarrollo profesional. Los resultados muestran que el 100% de los estudiantes han desarrollado al menos un proyecto en estas circunstancias y que el 70% de ellos está totalmente de acuerdo en que la aplicación del proyecto en una empresa real contribuye a su crecimiento profesional. Por otro lado, el 63% dijo que el PBL puede contribuir al desarrollo de habilidades personales y la adquisición de nuevos conocimientos. Finalmente, el 56% está totalmente de acuerdo en que el método de aprendizaje PBL debe llevarse a cabo en la mayoría de las asignaturas que asisten a lo largo de su educación universitaria. En conclusión, debido al impacto de esta metodología en la capacitación de los estudiantes, se deben adaptar más asignaturas a este esquema, aunque el tiempo para completar el proyecto es uno de los mayores obstáculos que enfrentan los estudiantes.

Keywords: Aprendizaje basado en proyectos; Practicas Profesionales; Competencias, Escenarios Reales de Aprendizaje, Habilidades.

7 Introduction

Sin duda, la formación práctica de un estudiante universitario es de gran relevancia tanto para el desempeño del profesional, como para su desarrollo personal y académico (Oyola y Padilla, 2012). En este proceso de formación, se destaca particularmente que las pasantías en empresas es un momento de "iniciación" en la vida profesional, así como por el tiempo requerido por la institución y por el grado particular. Las prácticas se convierten así en un escenario de aprendizaje de la vida real mediante la aplicación de conocimientos y habilidades desarrolladas en el aula que lo convierten en una experiencia personal y profesional. Al mismo tiempo que las pasantías son un componente curricular adicional, una parte sustancial y obligatoria de la mayoría de los grados en la educación superior (Raposo y Zabalza, 2011).

Aunque la mayoría de la educación profesional está diseñada en torno a un enfoque tradicional centrado en el instructor (conferencias centradas en el contenido), los graduados a veces tienen dificultades para generalizar el conocimiento a contextos del mundo real. Algunos programas profesionales han adoptado un enfoque de Aprendizaje Basado en Proyectos (PBL de ahora en adelante), una estrategia educativa que pone énfasis en el alumno, para desarrollar profesionales de nivel básico con fuertes habilidades en las áreas de pensamiento crítico y resolución de problemas, El trabajo en equipo, la autodirección y el aprendizaje permanente. En PBL el problema (que viene primero) sirve como base para la construcción del estudiante de conocimiento. Mientras que el contenido es importante, PBL también enfatiza el proceso: buscar información a través de la investigación de un tema, aplicar información a un problema en particular y generalizar el contenido y el proceso a situaciones y personas similares. (Luebben, 2005)

Los requisitos de la industria sobre lo que necesitan de los graduados de ingeniería, parecería poco probable que se satisfagan con un plan de estudios de ingeniería tradicional y la pedagogía "chalk and talk". Un enfoque en modo mixto con componentes basados en proyectos que aumentan en extensión, complejidad y autonomía de los estudiantes en los últimos años del programa, parece ser la mejor manera de satisfacer las necesidades de la industria, sin sacrificar el conocimiento de los fundamentos de ingeniería. Se ha demostrado que la profesión de ingenieros y académicos están familiarizados con los conceptos de los proyectos en su práctica profesional (Mills y Treagust, 2003).

La efectividad de PBL se mide en los tres dominios como se ve en la Tabla 1 del aprendizaje estudiantil identificado por el Consejo Nacional de Investigación (NRC) informe sobre el aprendizaje más profundo: cognitivo, intrapersonal e interpersonal. La NRC postuló que estos tres dominios abarcan las competencias de aprendizaje crítico del siglo XXI necesarias para el éxito en la Universidad y la carrera [Pellegrino y Hilton, 2012).

Tabla 27. Dominios y competencias del siglo XXI.

Dominios	Ejemplos de Competencias
Dominio Cognitivo: Competencias relacionadas con las habilidades de pensamiento, tales como razonamiento, resolución de problemas y memoria. Este dominio también incluye conocimiento de contenido y creatividad.	Habilidades de contenido académico Pensamiento crítico Alfabetización Tecnológica Escucha activa. Solución de problemas Creatividad
Dominio intrapersonal: Las competencias afectivas utilizadas para "establecer y lograr sus objetivos"	Autorregulación Metacognición Firmeza de carácter Flexibilidad
Dominio Interpersonal: Competencias utilizadas para expresar, interpretar y reaccionar a la información.	Comunicación Colaboración Resolución de conflictos Liderazgo

El aprendizaje basado en proyectos es una perspectiva integral centrada en la enseñanza al involucrar a los estudiantes en la investigación. En este marco, los estudiantes buscan soluciones a problemas no triviales, preguntando y refinando preguntas, debatiendo ideas, haciendo predicciones, diseñando planes y/o experimentos, recopilando y analizando datos, sacando conclusiones, comunicando sus ideas y hallazgos a otros, haciendo nuevas preguntas y creación de artefactos (Blumenfeld, Solloway, Marx, Krajcick, Guzdial y Palincsar, 1991).

A medida que los estudiantes encuentran y analizan sus proyectos, investigan las múltiples facetas de los problemas que pueden surgir durante la realización del proyecto, mientras buscan recursos de investigación válidos. A medida que los estudiantes hacen conexiones entre ideas, desarrollan nuevas habilidades y trabajan en una variedad de tareas, a menudo en grupos de trabajo cooperativo. Los estudiantes usan herramientas del mundo real para completar su investigación, y a menudo estas herramientas incluyen la amplia variedad de tecnologías disponibles en el aula: aplicaciones de software, dispositivos de proyección, internet, correo electrónico y multimedia. A medida que los estudiantes investigan, obtienen retroalimentación de entrenadores y expertos sobre la validez de sus ideas y fuentes (Aufdenspring, 2004).

Un proceso de aprendizaje requiere que tanto los profesores como los estudiantes asuman un papel más activo, un mayor compromiso compartido y, en el caso particular de los estudiantes, una mayor responsabilidad por su propio aprendizaje. A lo largo de las diferentes fases, se mantiene la base científica del aprendizaje basado en proyectos para generar procesos de aprendizaje en los que los alumnos no son receptores pasivos del conocimiento, sino que están inmersos en una experiencia pre profesional gracias al vínculo entre la universidad y la administración regional, Proyectos con contenido real, que obliguen a los alumnos a integrar el conocimiento que ya han adquirido de otros cursos con los nuevos conocimientos adquiridos en el desarrollo del proyecto. También se desarrollan competencias personales. Los estudiantes aprenden a trabajar en equipo, potenciando su personalidad y acercándolos a la realidad. (de los Rios, Cazorla, Diaz-Puente y Yague, 2010).

A través de las guías de aprendizaje y enseñanza, los estudiantes de ingeniería obtienen la oportunidad de adquirir autoconocimiento que les ayuda a alcanzar cualificaciones y cualidades profesionales como graduados en ingeniería. Es una tarea interesante y desafiante para que el personal y los estudiantes practiquen un nuevo proceso de aprendizaje y enseñanza. Los profesores encuentran interesante implementar el sistema e integrar la ingeniería y la tecnología en proyectos de manera significativa. Los miembros del personal consideran el método de aprendizaje a través de proyectos como un beneficio para todos los interesados, tales como estudiantes, industria, comunidad y universidad a través de proyectos orientados a los programas de aprendizaje basado en el aprendizaje. En Project Oriented Design Based Learning (Aprendizaje basado en el diseño orientado a proyectos), el personal y los estudiantes practican el diseño de ingeniería de manera significativa y pueden adaptarse fácilmente a las pautas de aprendizaje y enseñanza. (Chandrasekaran, Littlefair y Stojcevski, 2015)

En respuesta a estas tendencias mundiales, la Universidad Autónoma de Yucatán (UADY) enfatiza la constante formación y formación profesional de los estudiantes, a través de sus programas de grado impartidos en la Facultad de Ingeniería Química (FIQ de ahora en adelante), A través de iniciativas que ayudan a la incorporación de los estudiantes a escenarios reales de aprendizaje como la asignación de proyectos aplicados en empresas reales. Aquí es donde el profesional capacitado en la FIQ puede contribuir al desarrollo y fortalecimiento de estos programas de estudio. En el contexto FIQ, los estudiantes necesitan tener una visión clara de su mercado de trabajo y posibles actividades y proyectos para desarrollarse como profesionales. En el programa de pasantías profesionales, junto con los conocimientos impartidos en el currículo de la materia, así como los proyectos asignados en diversos temas, podrían afectar su desarrollo profesional en el corto y largo plazo. Es por ello que es necesario identificar la contribución de la metodología de aprendizaje basado en proyectos en el programa de pasantías de estudiantes de pregrado en Ingeniería Industrial Logística (IIL).

8 Objetivo y Alcance

Conocer si los estudiantes han utilizado la herramienta del aprendizaje basado en proyectos en las distintas asignaturas durante su formación y analizar el impacto que tiene esta metodología en la adquisición de nuevas competencias para su desarrollo profesional.

La investigación abarcó únicamente a estudiantes de cuarto y quinto año que hayan cursado materias de ingeniería aplicada de su carrera con proyectos integradores desarrollados en escenarios reales de aprendizaje.

9 Metodología

Debido a que la investigación es de tipo cualitativa y exploratoria, el tamaño de muestra de la investigación se definió en 30 casos (Hernández, Fernández y Baptista, 2010), conformados por alumnos de séptimo y noveno semestre de la Licenciatura dn Ingeniería Industrial Logística.

La investigación consta de la aplicación de un instrumento tipo encuesta mediante el uso de una escala de Likert (Likert, 1932), con base en los estudios de caso de (Gavin, 2011) y (Gómez, Rivas, Mercado y Barjola, 2009) de manera que se pueda evaluar el impacto que perciben los estudiantes en su formación en el uso del aprendizaje basado en proyectos.

La encuesta constó de un cuestionario de once preguntas, el cual fue elaborado mediante la herramienta de formularios de GoogleDrive© de manera estructurada y se administró mediante el uso de correo electrónico y redes sociales a los estudiantes de la muestra de la investigación. Toda la información recabada fue almacenada en la base de datos de esta herramienta para el análisis de los resultados obtenidos.

10 Resultados

Una vez aplicado el instrumento se obtuvieron los resultados siguientes. En la Figura 1, del total de la muestra, solo el 40% ha escuchado hablar sobre la técnica didáctica PBL, por otro lado, el 60% de los encuestados no ha escuchado hablar acerca del tema. Esto puede ser el resultado de la experiencia y conocimiento que han adquirido o no, en las empresas donde hayan desarrollado proyectos.

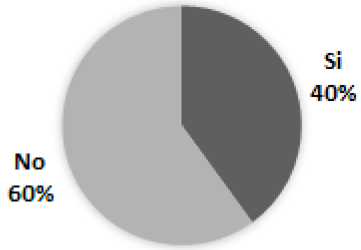

Figura 1. ¿Has escuchado hablar de la técnica didáctica de Aprendizaje Basado en Problemas/Proyectos (ABP o PBL)?

Por otro lado el 36% de los encuestados afirma que ha cursado alguna materia en la cual se utilizó esta metodología, el 37 % no han cursado materias que la utilicen y el 27% no está seguro o pertenecen al porcentaje que nunca ha escuchado sobre el PBL.

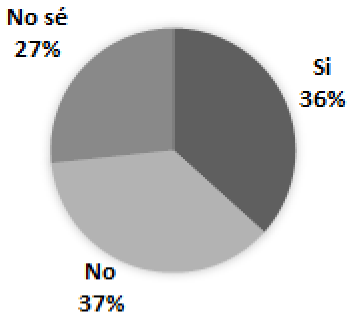

Figura 2. ¿Has cursado alguna materia que utilice la técnica didáctica de Aprendizaje Basado en Problemas (ABP o PBL)?

La mayoría de los alumnos encuestados aseguran que en la materia de “Sistemas de Calidad” han realizado proyectos en una empresa, obteniendo un total de 30 respuestas para esta materia como se muestra en la siguiente figura. En segundo lugar se encuentra la materia de “Abastecimiento” con un total de 26 respuestas, en tercer y cuarto lugar tenemos las materias de “Ventas” y “Simulación” con 18 y 15 respuestas respectivamente. Otras materias como “Planeación estratégica”, “Ingeniería de Métodos”, “Canales de Comercialización”, “Tecnologías de Información de Soporte Logístico (TISL)” y “Seguridad e Higiene”, obtuvieron menos respuestas pero a pesar de esto, la aplicación de los conocimientos adquiridos en estas materias para la realización de proyectos en las empresas es viable, es probable que dependiendo de cómo el profesor desarrolle el curso haya influido en el porcentaje obtenido.

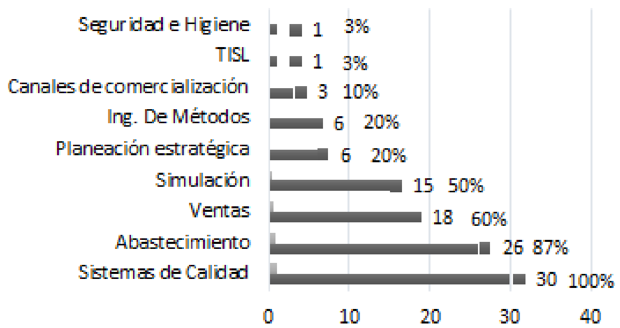

Figura 3. ¿En qué asignaturas de la carrera llevaste a cabo un proyecto en una empresa real.

El 27% de los encuestados respondieron que están totalmente de acuerdo (TD) en que realizar proyectos en las empresas resulta interesante y atractivo, el 73% está de acuerdo en ciertos aspectos (AA).

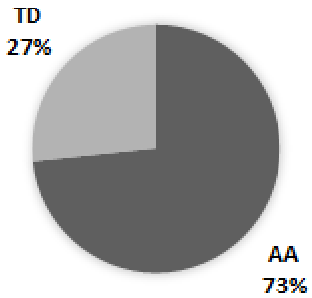

Figura 4. ¿Los proyectos en empresas reales en los cuales has trabajado te resultaron atractivos e interesantes?

Un 63% de los alumnos está de acuerdo en que ciertos aspectos (AA) de realizar proyectos en las empresas les ayuda a generar mayores conocimientos, 30% están totalmente de acuerdo (TA) y al 7% le es indiferente (I), como se aprecia en la siguiente figura.

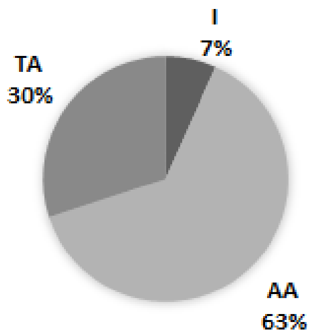

Figura 5. ¿Obtuviste mayores conocimientos gracias a este tipo de proyectos?

En la *Figura 6* se obtuvo que el 73% de los alumnos encuestados están totalmente de acuerdo (TA) que es importante que los estudiantes desarrollen proyectos académicos en las empresas, 23% está de acuerdo en ciertos aspectos (AA) y solo un 4% se encuentran totalmente en desacuerdo (TD).

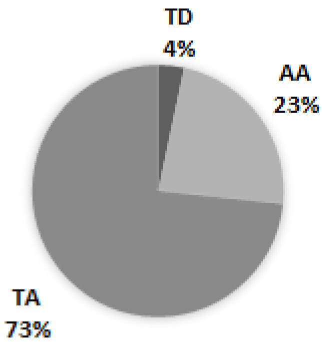

Figura 6. ¿Crees que es importante que los estudiantes de tu licenciatura realicen proyectos académicos en empresas reales?

En la Figura 7, se observan cuales fueron los factores que tuvieron que ir venciendo los estudiantes para poder concluir el proyecto el 58% consideraron que el tiempo fue el mayor obstáculo, el 22% afirmaron que el dueño o gerente de la empresa, mientras que el desconocimiento de los objetivos del proyecto y las habilidades de comunicación fueron otros factores que afrontaron durante la realización del proyectos.

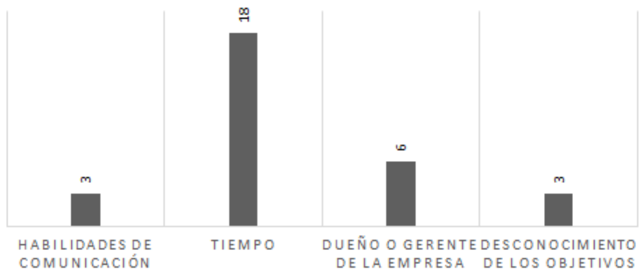

Figura 7. ¿Cuál crees que fue el más grande obstáculo que tuviste que vencer para realizar un proyecto de este tipo?

Las competencias que los estudiantes desarrollaron al utilizar esta metodología en el proyecto realizado en la empresa con mayor frecuencia fueron: “Resolución de conflictos”, “Comunicación” y “Flexibilidad” como se muestra en la siguiente figura.

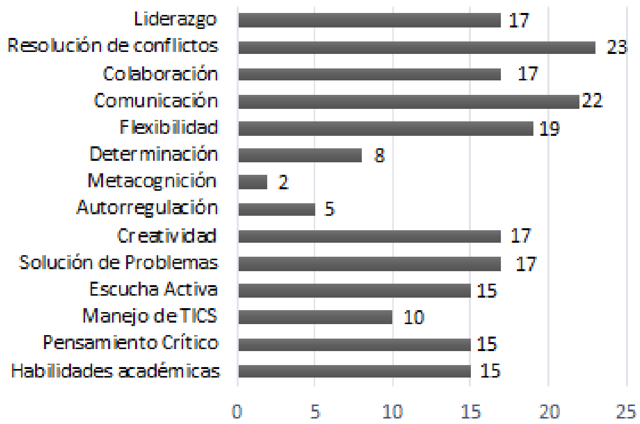

Figura 8. ¿Qué tipo de competencias consideras haber desarrollado en los proyectos en los que estuviste involucrado?

En la Figura 9 se aprecia que el 73% de los estudiantes se encuentran de acuerdo en ciertos aspectos (AA) que el trabajo en equipo es más importante que las habilidades personales para poder realizar un proyecto en una empresa, 17% están totalmente de acuerdo (TA) y el 10% les es indiferente.

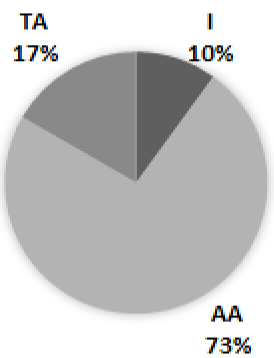

Figura 9. Para poder llevar un proyecto en una empresa es más importante el trabajo en equipo que mis habilidades personales.

El 70% de los encuestados están totalmente de acuerdo que la realización de proyectos de este tipo, aportan crecimiento profesional, el 30% restante se encuentra de acuerdo en ciertos aspectos como se muestra a continuación.

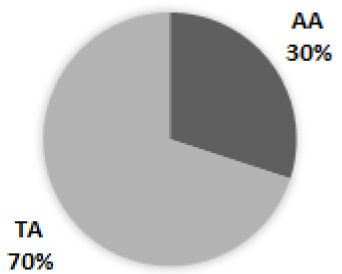

Figura 10. ¿Consideras que la realización de este tipo de proyectos aporta crecimiento profesional?

Finalmente el 56% de los alumnos está totalmente de acuerdo (TA) en que el método de aprendizaje PBL debe aplicarse en la mayoría de las materias que se imparten a lo largo de la Licenciatura, 27% están de acuerdo en ciertos aspectos (AA) y el 17% son indiferentes ante este método.

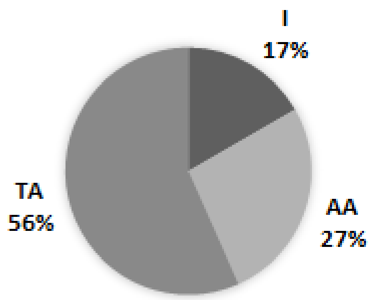

Figura 11. ¿Crees que este método de aprendizaje debe efectuarse en la mayoría de las materias que cursaste en la carrera?

11 Conclusiones

Con los resultados obtenidos podemos concluir que un 60% de los encuestados no había escuchado sobre el PBL y que no estaban seguros de haber cursado alguna materia donde se utilice. Esta metodología permite a los estudiantes desarrollar nuevas competencias, ya que los proyectos les parecen atractivos y están de acuerdo en realizarlo en empresas reales.

Es bastante interesante que los estudiantes opten por dar prioridad a competencias intrapersonales, relacionadas con la comunicación con otras personas, esto indica que éste es el principal factor al que se enfrentan al utilizar esta metodología en escenarios reales y que la UADY como formadora de profesionales debe de hacer énfasis en proveer a sus alumnos de las herramientas necesarias para desarrollar sus competencias y habilidades.

Se detectó que el 100% de los alumnos encuestados ha tenido por lo menos una asignatura en la carrera en donde se aplica el PBL y que todos los encuestados realizaron un proyecto en una empresa en la materia de “Sistemas de Calidad” la cual se imparte en el segundo año del plan de estudios y es su primer acercamiento a un ambiente real de aprendizaje. El 50% de los estudiantes están de acuerdo que la metodología del aprendizaje basado en proyectos se aplique en un mayor número de asignaturas.

La utilización de esta metodología no se realiza de una manera formal, es decir no se les imparte la teoría paso a paso, sino que aplican conocimientos adquiridos en el salón de clases y van desarrollando las competencias necesarias durante el desarrollo del proyecto.

Para finalizar con éxito el proyecto los estudiantes se tuvieron que enfrentar a varios factores como el tiempo y la poca colaboración de los directivos o dueños de las empresas.

Finalmente las competencias que afirman haber desarrollado durante la realización del proyecto fueron "Resolución de conflictos", "Comunicación" y "Flexibilidad" afirmando que el trabajo en equipo es el factor principal para tener éxito en el proyecto. Por otro lado tambien afirmaron haber adquirido nuevos conocimientos y crecimiento profesional.

La realización de esta investigación ha permitido conocer los beneficios de utilizar el PBL en entornos reales de aprendizaje y su aceptación entre los estudiantes y se propone como seguimiento de la investigación hacer llegar estos resultados a las autoridades de la escuela así como formalizar su utilización y difundir entre los profesores la misma.

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iTEC Action!: Perception, Achievements and Challenges: Proposals for solving social problems – interdisciplinary online collaborative work

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Abstract

The Tecnologico de Monterrey TEC 21 educational model aims, in different senses, to adapt the teaching-learning process to the present times through an educational design based on challenges and competences both transversal and disciplinary, in the 42 professional careers. This has triggered the generation of new didactic projects that have the objective of laying the foundations of this model. One of these was implemented in September 2015 during three weeks, an experience in which students were involved in solving a challenge outside the classroom when they carried out a project in which they demonstrated their knowledge, regardless of discipline. Because, for various reasons, some students could not attend the face-to-face design of this activity due to work commitments, previously scheduled study trips, diseases, etc.; teachers of different areas designed the TEC Action! It is a project designed for *Semana i*. Only students who could not participate in a regular activity programmed for that week could register in this project. They also required the approval of their advisor. The objective of *iTEC Action!* was to confront the participants with a challenge or problem of a social and humanitarian nature. They were also instructed to come up with viable and innovative solutions that would enhance the quality of life of those who were going through a difficult, if not critical, situation. At the end, and after they had presented the different options they came up with, these undergraduates answered a survey prepared by the professors who were in charge. The answers these students provided showed that they were competent and made used of the different skills they practiced in their undergraduate classes. Of course, as with any new project, there is room for improvement.

Keywords: Interdisciplinary, challenge, competent, on line.

TEC Action!: Percepción, Logros y Retos: Propuestas de solución a problemáticas sociales - trabajo colaborativo interdisciplinario en línea

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Resumen

El Modelo Educativo TEC 21 del Tecnologico de Monterrey pretende, en diferentes sentidos, adecuar el proceso de enseñanza-aprendizaje a los tiempos actuales mediante un diseño educativo basado en retos y competencias tanto transversales como disciplinares, en las 42 carreras profesionales que ofrece el Tecnológico de Monterrey. Esto ha detonado la generación de nuevos proyectos didácticos que tienen el objetivo de sentar las bases de este modelo. Uno de estos se implementó en septiembre de 2015 durante la denominada Semana i, experiencia en la que los alumnos se involucraron en la solución de un reto fuera de las aulas al realizar un proyecto en el que demostraron sus conocimientos, independientemente de la disciplina. Ante el hecho de que, por diversos motivos, algunos alumnos no pudieran atender el diseño presencial de esta actividad por compromisos de trabajo, viajes de estudios programados previamente, enfermedades, etc.; profesores de diferentes áreas diseñaron en forma y contenido la opción de *TEC Action*! Éste fue un proyecto de Semana i, diseñado para responder a las necesidades de un grupo de estudiantes, quienes no podían participar en las otras actividades presenciales. El objetivo fue que se enfrentaran a retos de carácter social y propusieran soluciones innovadoras, viables y que contribuyeran a mejorar la calidad de vida de los sujetos implicados en la problemática por resolver. Al final de la actividad, los estudiantes contestaron una encuesta que permitió analizar los resultados de esta experiencia, los cuales fueron positivos en general, ya que se demostró que los estudiantes aplicaron una serie de competencias que favorecieron su formación integral. Naturalmente se detectaron también áreas de oportunidad, tales como un replanteamiento de los retos y una mejor selección de los profesores tutores.

Palabras clave: Reto, competencia, enseñanza/aprendizaje, virtual.

1 Introducción

La sociedad actual exige a la educación superior la formación de profesionistas poseedores de competencias necesarias para enfrentar adecuadamente el Siglo XXI, tales como el pensamiento crítico, solución de problemas, habilidades de comunicación, entre otras. El Modelo Educativo TEC 21 del Tecnológico de Monterrey (ITESM), adecua el proceso de enseñanza-aprendizaje a los tiempos actuales mediante un diseño educativo basado en retos y competencias tanto transversales como disciplinares, en las 42 carreras profesionales que ofrece el Tecnológico de Monterrey. Esto ha detonado la generación de nuevos proyectos didácticos que tienen el objetivo de sentar las bases de este modelo. De acuerdo con Álvarez (2002), la demanda de profesionales realmente competentes para enfrentar los retos que la sociedad demanda, no puede basarse en los modelos tradicionales atomizados o parcelarios que carecen de integración y una evaluación integral de los aprendido. Los desarrollos de estos modelos educativos exigen una formación profesional integral y holística proveniente de situaciones reales donde el trabajo en equipo y la utilización del conocimiento de manera interdisciplinaria se aplican en los contextos educativos de esquemas completamente diferentes. Uno de estos se implementó en septiembre de 2015 durante la denominada *Semana i*, experiencia en la que los alumnos se involucraron en la solución de un reto fuera de las aulas al realizar un proyecto en el que demostraron sus conocimientos, independientemente de la disciplina. Ante el hecho de que, por diversos motivos, algunos alumnos no pudieran atender el diseño presencial de esta actividad por compromisos de trabajo, viajes de estudios programados previamente, enfermedades, etc.; profesores de diferentes áreas diseñaron en forma y contenido la opción de *TEC Action*! (Semana i en línea). En seguida se describe su diseño, implementación y resultados.

2 Desarrollo

La propuesta de i*TEC Action*! es una actividad con un formato totalmente diferente al tradicional, diseñada para alumnos de diversas carreras y semestres. Las competencias que se pretendieron impulsar en esta primera experiencia de la Semana i en línea fueron: emprendimiento e innovación, pensamiento crítico y comunicación oral y escrita. Se documentaron los resultados de la investigación cuantitativa y cualitativa de la *Semana i* en línea en el año 2015. El presente trabajo indaga los logros y retos de esta experiencia con el objetivo de identificar sus áreas de oportunidad y proponer mejoras en el diseño para una futura implementación. EL objetivo de esta investigación fue el analizar el impacto de la Semana i en línea en los alumnos que participaron, con la finalidad de evaluar el grado de desarrollo de competencias derivadas de actividades en las que no hay un involucramiento presencial entre los participantes y fortalecer el pensamiento crítico en relación con problemáticas sociales, muchas veces ajenas a los estudiante, desde un sentido humano para ofrecer propuestas de solución.

2.1 Marco teórico

Actualmente, la formación de los estudiantes en el Tecnológico de Monterrey, se ha ido adecuando para desarrollar y reforzar en los estudiantes sus competencias profesionales en una variedad de experiencias vivenciales que son tomadas del entorno real que rodea al estudiante, que combinadas con otras habilidades transversales fortalecen su habilidad para solucionar problemas y desarrollar su pensamiento crítico. Estos enfoques son intencionados en ambientes que demandan una mayor complejidad comparado a los ambientes tradicionales de enseñanza en donde solo se enfatizan la memorización desde una perspectiva unilateral, la del profesor. Bajo la perspectiva de una educación basada en competencias, la pedagogía debe de cambiar asi como su forma de evaluarla. (Vallejo y Molina, 2014) La conexión entre la realidad y el poner altas expectativas cuando los estudiantes trabajan conectados con problemas de la vida real incrementa notablemente sus competencias profesionales (Gosselin, et al 2013). Sobre esto es importante recalcar que la educación basada en competencias busca que se dé una conjunción entre lo social, lo afectivo, las habilidades del conocimiento, las motoras, psicológicas y sensoriales de una manera tal que el estudiante que se desempeñe en la vida laboral pueda tener una interacción efectiva en los ámbitos sociales, éticos y profesionales. Asimismo, este modelo trata de un enfoque integral de la educación que se fundamenta en que las experiencias de aprendizaje de los alumnos a través de experiencias del mundo real y complejas que se sustentan no en ejercicios descontextualizados sino en actividades pensadas que retan el intelecto y las habilidades de los estudiantes. (Argudín, 2006; Vallejo y Molina, 2014). Para la Semana i en línea cabe resaltar el concepto del profesor como asesor en el sentido de que “tiene confianza y respeto por las posibilidades de desarrollo que tiene cada alumno, y bajo esa perspectiva… interviene buscando el mejor desarrollo… En esa relación humana ayuda al alumno a tomar conciencia de sí mismo y de sus responsabilidades, estimulando su capacidad de observar la forma en que el ambiente influye sobre su conducta (Ayala, 2002, p.48). Así en relación con el Modelo Educativo TEC 21 se parte de la premisa de que: los estudiantes deben demostrar sus conocimientos enfrentando y solucionando retos a través de sus competencias transversales y disciplinares identificadas desde el diseño de la misma actividad, en las que el profesor juega el papel de asesor del proceso de la solución de un reto específico.

El aprendizaje basado en retos y el que se obtiene a partir de la solución de problemas tienen sus orígenes en las aportaciones de Dewey, Piaget, Patrick, Rogers y Kholbs, quienes realizaron estudios significativos del aprendizaje que surge a través de la experiencia (*EduTrends*, 2015). En este sentido, la adquisición del aprendizaje se da de una forma más efectiva cuando los alumnos participan de manera activa en experiencias reales y abiertas. Lo relevante de esta estrategia (Aprendizaje Basado en Problemas) es que, en lugar de recolectar datos e información, que es lo habitual en la educación convencional, los estudiantes se enfrentan a un problema que ellos mismos detectan y trabajan en equipo hasta encontrar su solución, particularmente cuando se realizan de manera colaborativa (Poot-Delgado, 2013). Es importante resaltar que el trabajo colaborativo es también relevante en el momento de solucionar el reto identificado. Albanese y Mitchel (1993) señalan que los estudiantes trabajan en pequeños grupos compartiendo su experiencia al observar, analizar, discutir y reflexionar sobre actitudes y valores que difícilmente se contemplan en la enseñanza expositiva. Además, lo hacen de una forma integral y multidisciplinaria, pues Poot- Delgado (2013) menciona que los estudiantes consideran puntos de vista histórico, social, psicológico, etc., lo cual resulta más enriquecedor en la búsqueda de propuestas y soluciones. Estudios realizados con estudiantes bajo esquemas de aprendizaje asistido con profesores y en esquemas en línea demostraron que las actitudes de trabajo son similares y que el desempeño de los estudiantes no está influenciado por el ambiente de aprendizaje (asíncrono o síncrono), ni por el género de los estudiantes (Hill, 2010).

De acuerdo con Álvarez (2002), actividades que estén situadas en contextos reales, permitirán desarrollar algunas de las competencias profesionales más importantes en los alumnos tales como la recolección, análisis y organización de la información, el trabajo con otras personas y en equipo, el hacer uso de la tecnología, ser capaz de hacer una relación intercultural, como competencias principales.

2.2 Planteamiento del problema

El desarrollo de esta actividad planteó varios desafíos, tanto por el tiempo como por el formato asíncrono de interacción entre los estudiantes. Además del desarrollo de competencias, varias preguntas de investigación se plantearon a fin de mejorar tanto su implementación como su evaluación. Para este reporte se consideraron las siguientes: ¿cómo esta actividad i*TEC Action*! (Semana i en línea) impulsó el desarrollo de las competencias transversales de emprendimiento e innovación, pensamiento crítico y comunicación oral y escrita?; ¿de qué forma satisfizo las expectativas de desarrollo de competencias y aprendizaje desde el punto de vista de los alumnos? La hipótesis planeada al inicio del trabajo fue que el diseño y la implementación de la actividad *iTEC Action!* (Semana i en línea) aplicada a los alumnos de carreras profesionales del Campus Monterrey, en septiembre de 2015, lograría desarrollar las competencias para las que se diseñó buscando la satisfacción plena de los alumnos, como 1) Identificar los logros con base en el objetivo de esta actividad; 2) Identificar las áreas de oportunidad de la misma; 3) Proponer mejoras en el diseño y su implementación.

2.3 Método

La experiencia señala que durante la implementación de la Semana i presencial, surgen situaciones que impiden a ciertos estudiantes incorporarse de tiempo completo a su actividad regular debido a enfermedad, compromisos laborales, entre otros. Estos estudiantes fueron inscritos en esta actividad en línea diferente que les permitió desarrollar algunas de las competencias profesionales, abordando problemáticas sociales importantes. Al considerar que los alumnos son de distintas carreras profesionales, la integración multidisciplinaria ofrece una oportunidad inigualable de que interactúen y complementen sus habilidades para llegar a una conclusión y que, además de desarrollar las competencias que se hayan planeado, puedan sentirse motivados a ofrecer soluciones realistas. En esta actividad, el reto fue investigar un problema social con el fin de proponer alternativas de solución; el trabajo fue colaborativo y en línea, ya que el diseño de la actividad los guio paso a paso para que gradualmente desarrollaran su propuesta de solución. Esto exigió de los estudiantes una coordinación y toma de decisiones que favoreciera el cumplimiento de la actividad y el tiempo destinado para ello. Tomando en cuenta que 333 estudiantes fueron inscritos en la actividad, se tuvo la cooperación de una cantidad de 17 profesores tutores para conformar una cantidad de 69 equipos. Los pasos a seguir fueron: 1. Asignación del tema o reto; 2. Investigación del marco teórico; 3. Metodología de trabajo; 4. Análisis de resultados; 5. Conclusiones (propuesta escrita de solución); 6. Bibliografía; 7. Producción de un video de reflexión. Durante los meses de septiembre y octubre de 2015, 333 alumnos se inscribieron para conformar 69 equipos virtuales de trabajo de cinco integrantes, a quienes se les asignó analizar un reto y proponer alternativas de solución a uno de los siguientes temas sociales: 1) Los franeleros; 2) Accesibilidad dentro del distrito TEC; 3) Trabajo infantil; 4) Sustentabilidad en el Distrito TEC; 5) Migrantes; 6) Comercio informal. Se elaboró una encuesta para medir el grado de satisfacción y percepción de los estudiantes sobre la experiencia y poder evaluar aspectos del desarrollo de competencias, organización de la actividad, tutoreo de los profesores asignados, la implementación de las actividades, le grado en que la problemática de la realidad se conectó, etc., y se colocó un espacio virtual en internet para orientar a los estudiantes en el proceso que vivirían.

Los estudiantes fueron guiados en su proceso de desarrollo de competencias bajo el siguiente criterio:

2.3.1 Fase I. Introducción

Durante esta primera fase, los estudiantes fueron instruidos a desarrollar una justificación que deberá demostrar la relevancia del tema para la sociedad actual. Elaborar preguntas de investigación que generan interés y preocupación por el tema, aun cuando no se cuentan con todas sus respuestas. Plantear una hipótesis enmarcada en un período y espacio definidos, es decir, indicando de manera precisa en la problemática actual y real a investigar en un lugar y tiempo específico, tomando como referencia el tiempo a que duraría la actividad. Proponer como equipo, objetivos que se desearan lograr, expresados con verbos en infinitivo y numerados; máximo tres.

2.3.2 Fase II. Marco Teórico

El propósito del marco teórico es reunir la mayor información posible sobre la problemática de estudio. Su función es ser una plataforma conceptual y de conocimientos para que, con base en esta, se analice el objeto de estudio para presentar propuestas de solución. A fin de identificar fuentes de información confiables, los estudiantes fueron instruidos en buscar propuestas en fuentes tales como revistas científicas de investigación académica, revistas científicas de divulgación del conocimiento, noticias, reportajes, entrevistas entre otros, de periódicos y revistas informativas, libros propios de alguna disciplina académica desde los cuales se pueda abordar la comprensión y solución a la problemática en cuestión.

2.3.3 Metodología de trabajo y Análisis de información

El propósito de esta fase es reunir información que se considere pertinente para demostrar la problemática desde sus antecedentes y su situación actual. Mediante un patrón de organización de información deductivo, se denomina a un primer bloque marco contextual en el que se presenta la situación que prevalece actualmente desde lo más general o global en el mundo. A continuación, se pasa al siguiente bloque llamado marco referencial en el que se hará reseña de un caso de estudio delimitado en un lugar y condiciones específicas que lo hacen muy particular. Para ambos bloques de esta fase se sugirió acudir, entre otras fuentes en el orden de importancia, a indicadores estadísticos o documentación gráfica de la problemática, información recabada mediante la elaboración de encuestas, entrevistas con personas o líderes de opinión que se considere pertinente, reportes de trabajo y trabajos de instancias públicas, privadas, organizaciones no gubernamentales o de la sociedad civil por mencionar algunas y datos pertinentes provenientes del marco teórico

2.3.4 Fase III. Propuestas de solución

Con la experiencia de haber conformado y conocido los marcos teórico, contextual y referencial, los estudiantes acuden a su conocimiento, especialidad, experiencia y capacidad emprendedora para formular de manera interdisciplinaria propuestas innovadoras de solución o disminución de la problemática. Las propuestas se harían llegar a instancias correspondientes por medio del Tecnológico de Monterrey.

2.3.5 Conclusiones

En esta sección los estudiantes pusieron en perspectiva los elementos escritos en la introducción: las preguntas de investigación y comentar si con este trabajo se respondieron; analizar la hipótesis para interpretar si es válida o no; así como los objetivos para explicar si se lograron o en qué medida. Cabe señalar que, el reto asignado a los equipos proveyó de información relevante y valiosa no solo para el desarrollo de las competencias de los estudiantes sino también para investigadores de problemáticas sociales, el lector del tema y el futuro investigador que retome la problemática y algunas de las instituciones involucradas en las problemáticas sociales. El documento final deberá considerar el estilo de citación APA y extensión de 8 a 10 cuartillas. y contener las referencias de las fuentes de información utilizadas en la investigación además de fuentes relevantes a las que se acudió, pero que no se mencionan en el documento.

2.3.6 Elaboración de presentación oral en video.

Durante la parte final del proyecto, Cada estudiante por separado fue instruido en expresar en forma oral su experiencia vivida e incluirá en sus reflexiones cualquier aprendizaje adquirido al vivir la experiencia. Se requirió que destacaran el impacto de la actividad en lo referente a su responsabilidad ética y ciudadana hacia los problemas que enfrenta el entorno que rodea la vida estudiantil, tanto en el área que enmarca el DISTRITO TEC como otras áreas de la ciudad de Monterrey. Además, los estudiantes resaltarían la manera en que la actividad de la semana i, así como las propuestas de solución desarrolladas por su equipo, cambiaron su perspectiva de las cosas.

3 Resultados

La mayoría de los estudiantes participantes en esta actividad fueron principalmente de la Escuela de Ingeniería y Tecnologías de la Información (44.4%) de la Escuela Nacional de Ciencias Sociales y Humanidades (35.3%), Escuela Biotecnología (12.0%) y de la Escuela de Arquitectura y Arte Digital (8.3%), compuestos principalmente por un 50% de hombres y mujeres por igual. Del total de alumnos encuestados (133), una gran parte de ellos trabajaba, sea de tiempo parcial o de tiempo completo, puesto que muchos están en semestres terminales (86%) mientras que el resto de la muestra de estudiantes en semestres inferiores estaban en semestres dentro del primer tercio. La integración multidisciplinaria no tuvo mayor efecto en el desarrollo de las competencias que se buscaron desarrollar, puesto que, en la evaluación de su desempeño, el 78.9&% de ellos consideró que fue irrelevante dado que los objetivos a lograr estaban bien delineados desde el inicio. Debido a que los retos de esta actividad fueron asignados a los alumnos de manera aleatoria, eso contribuyo a que un porcentaje del 57 % no se sintiera del todo confortable con el tema asignado. Esto lo consideramos con un factor a mejorar para el futuro, puesto que debido a lo heterogéneos de los grupos los estudiantes tuvieron mayor dificultad para organizarse y lograr los objetivos planteados (ver Figura 1). Diferentes problemas de participación entre estudiantes con diversidad de actividades, la falta de información para atender los retos planteados, así como la asincronía en tiempo planteo dificultades importantes durante esta actividad.

Figura 15 Principales obstáculos enfrentados en la solución de los retos asignados a estudiantes participantes en la Semana i i iTEC Action en el año 2015. Actividad implementada dentro del modelo educativo TEC 21 en Monterrey, N.L. (México).

Sin embargo, algunas de estas dificultades fueron solucionados cuando los estudiantes utilizaron diferentes medios electrónicos para organizar su trabajo de manera que se cumplieran con los objetivos planteados. Como se puede observar en la Tabla 1, Facebook se constituye en la principal plataforma de comunicación para trabajos colaborativos y asíncronos seguido de la plataforma Google Drive, y la utilización de la mensajería instantánea vía WhatsApp, y la utilización del correo electrónico constituyen los medios que son menos utilizados en comparación con los medios instantáneos de las redes sociales. Aun y con esto, varios estudiantes encontraron valioso la organización de reuniones presenciales o a través de los foros más convencionales como es el caso de la plataforma de Blackboard.

Tabla 28. Principales medios electrónicos empleados por estudiantes de diversas disciplinas para favorecer la comunicación y resolución de los retos planteados en la Actividad de Semana i en el año 2015

Medios electrónicos	%
Facebook	78.7
Google Drive	62.5
Correo electrónico	59.6
WhatsApp	54.4
Foro em Blackboard	19.9
Reuniones presenciales	14.9

Los retos, fueron evaluados de una manera diferente entre los grupos de estudiantes. Por ejemplo, como se muestra en la gráfica 2, los hombres consideraron de una manera más retadora los temas que recibieron aleatoriamente, en tanto que las ¡mujeres se sintieron un tanto menos atraída a la problemática presentada dentro de los mismos grupos de trabajos. Este fenómeno puede bien ser comprendido si se considera que los estudiantes tienen circunstancias muy diferentes durante el cumplimiento de la actividad, tales como nivel del semestre inscrito o estudiantes con un trabajo parcial o completo.

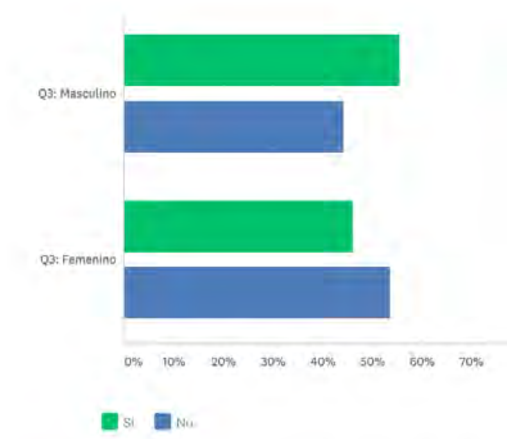

Figura 16. Percepción de los estudiantes sobre si los retos los consideraron desafiantes o no durante la Semana i i iTEC Action desarrollada durante el año 2015 en Monterrey, N.L. (México).

Con respecto a algunas de las competencias a evaluar, en la Figura 3 se aprecia la percepción de los alumnos con respecto a la habilidad de comunicación oral y escrita. Del grupo de estudiantes del género masculino, el 79.7% de los estudiantes consideraron que su habilidad para comunicarse había sido sobresaliente en tanto que en el grupo de las estudiantes del género femenino este porcentaje fue del 86%, un 10% más que el grupo de los hombres.

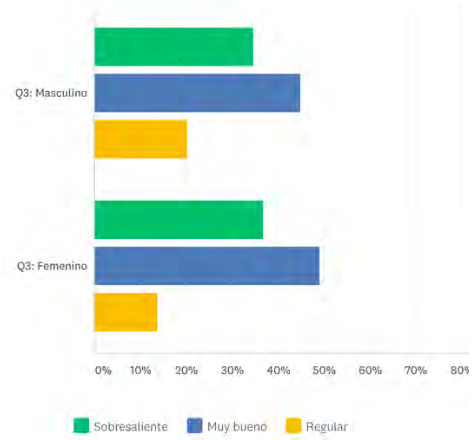

Figura 17 Percepción de los alumnos sobre el desarrollo de sus competencias oral y escrita durante el proyecto de Semana i i iTEC Action desarrollado en el año 2015 en Monterrey, N.L. (México)

Con respecto a la competencia de solución de problemas, como se puede apreciar en la figura 4, que para los estudiantes del género femenino hubo una mayor cantidad de estudiantes que consideraron la solución poco innovadora comparado con el grupo de los estudiantes de género masculino. Sin embargo, en ambos grupos, la gran mayoría de los estudiantes se sintieron satisfechos por el abordaje que hicieron a sus diferentes problemas (Soluciones muy innovadoras + Soluciones innovadoras), en el caso de los hombres este porcentaje fue de un 81.2, en tanto que, en el grupo de las mujeres, solamente fue del 68.2%, quienes en general no se sintieron tan satisfechos por las propuestas que como equipo se presentaron durante el proyecto.

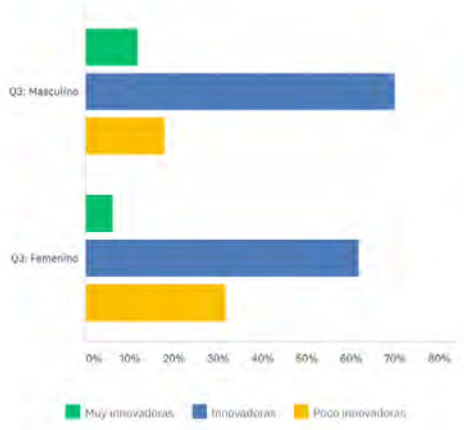

Figura 18 Percepción de los estudiantes del género masculino y femenino con respecto a lo innovadoras de sus soluciones a los retos planteados durante la Semana i iTEC Action, durante el año 2015 en Monterrey, N.L. (México)

El desarrollo de estas actividades generalmente presenta retos y dificultades que al inicio de los proyectos se presentan durante la integración de los grupos de trabajo, sin embargo los estudiantes finalmente resolvieron sus complicaciones porque en términos generales la gran mayoría de los estudiantes 3/4 de los estudiantes que respondieron la encuesta se percibieron con una actitud dispuesta y colaborativa en tanto que un ¼ de la muestra de estudiantes se percibió indiferente o más individualista. (ver figura 5)

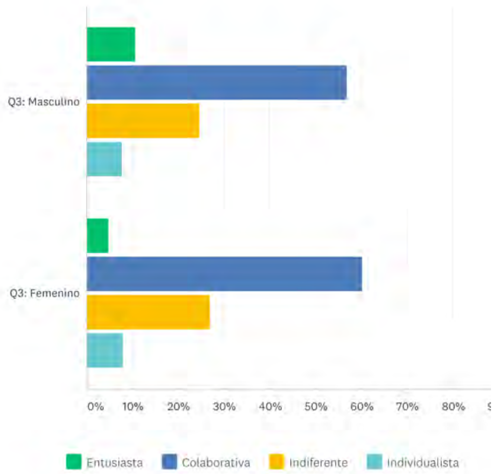

Figura 19 Percepción de los estudiantes sobre su actitud con respecto al trabajo desarrollado con el resto de sus compañeros de proyectos durante la semana i iTEC Action desarrollada en Monterrey, N.L. (Méx

Además, la competencia de solución de problemas, comunicación oral y escrita, los estudiantes afirmaron que durante la semana i que se desarrolló en los meses de septiembre y octubre, otras competencias adicionales: como la de liderazgo, identificada por el 58% de los alumnos, la de Pensamiento Crítico necesaria para ofrecer propuestas de solución o identificar cuestiones asociadas a las problemáticas identificadas fue identificada por el 59% de los estudiantes. La competencia de ética fue identificada por el 44% de los participantes y principalmente asociada en temas como la de marginación, trabajo infantil entre otras.   Asimismo, el equipo docente observó que durante el proyecto se desarrollaron otras competencias no declaradas explícitamente como la del Trabajo en equipo y la de Ciudadanía y compromiso social identificada por el 77% de los estudiantes que participaron en la encuesta aunque un menor porcentaje (23%) no se sintió así.

4 Discusión

iTEC Action! (Semana i en línea) puso a prueba la habilidad de los estudiantes para comunicarse virtualmente y lograr los objetivos que se plantearon, a pesar de que hubo algunos alumnos poco participativos; así mismo, debido a la escasa información accesible sobre el tema seleccionado, en algunos casos tuvieron que realizar trabajo de campo para la recolección de los datos. Actividades como las que se está fundamentando el modelo de educación TEC 21, conjunta el aprendizaje vivencial con la experiencia de los profesores, de manera que las habilidades cognitivas, afectivas y procedimentales favorece una preparación mas efectiva para enfrentar la vida laboral en una sociedad cada vez más compleja. (Vallejo y Molina, 2014). Además de las competencias identificadas anteriormente para esta actividad, los estudiantes expresaron que pudieron percibir en su desarrollo las siguientes competencias: ética y compromiso con el desarrollo sostenible. Realizar esta actividad en esta modalidad es en sí ya un aprendizaje en muchos sentidos, por lo que esta e constituye un aspecto muy favorable en la formación profesional del alumno que confirma que los estudiantes pueden desarrollar otras competencias de manera asíncrona. Graham y Scarborough (1999) reconocen que, en virtud de las muchas complicaciones en el desarrollo de actividades, muchos otros recursos mediados por la computación son utilizados como herramientas importantes para reducir el problema de mantener la enseñanza separada del aprendizaje. En la medida que las personas trabajan juntas, poco a poco van desarrollando una serie de competencias que de manera individual seria muy complicado desarrollar, y los esfuerzos de los estudiantes participando en las actividades de enseñanza, son mucho más efectivas que la simple transmisión de conocimientos tradicional. La experiencia vivida de los estudiantes durante esta Semana i *iTEC Action* demostró que sin importar las competencias profesionales principales en los programas de educación curricular, los estudiantes deben de exigirse más así mismo y con sus grupos de trabajo para enfrentar los problemas de sus comunidades con una perspectiva de mente abierta, reconociendo que las soluciones en muchos casos estarán muy por fuera de sus conocimiento y que las verdaderas soluciones integrales exigen la colaboración entre muchos grupos. El conocimiento y las posibilidades de solución a problemas sociales puede estar mas allá de los límites de los conocimientos y experiencias de los estudiantes.

Veerman y Veldhuis-Diermanse (2001), trabajando con grupos asíncronos vía tecnología computacionales, señaló que los problemas a los que se enfrenten los estudiantes bajo estas metodologías, deben de ser orientados con preguntas abiertas y con preguntas con diferentes perspectivas a fin de ofrecer una variedad de soluciones. La ventaja de ofrecer un sistema planeado y organizado para la solución de los problemas como se ofreció en esta Semana i, con la modalidad en línea, favorece mucho la planeación y ofrecimiento de soluciones a problemas determinados. De la misma manera, este proyecto promovió el trabajo multidisciplinario colaborativo, pues los integrantes de los equipos fueron de diferentes carreras, semestres y con un contacto virtual. Una vez identificada esta ventaja, se convirtió en área de oportunidad para mejorar el diseño desde esta estrategia didáctica.

5 Conclusiones

Definitivamente, el diseño de la actividad *TEC Action*! tuvo logros, pero a su vez tiene retos; es decir, tiene notables áreas de oportunidad que serán retomadas en la próxima edición, 2016; entre estas se considera que: el profesor asesor de esta actividad debe ser un docente sensible y preparado didácticamente para orientar el proceso de solución de problemas. Para mejorar el diseño y su implementación se sugiere que los retos y competencias estén muy bien identificados por parte de los profesores tutores y de los alumnos participantes.

Finalmente, con respecto a la hipótesis, tomando en cuenta las encuestas discutidas anteriormente, se comprobó la validez de la misma, aunque por supuesto, como siempre sucede al inicio de todo proyecto, hay áreas de oportunidad, puesto que no logró satisfacer del todo las expectativas de los alumnos, aunque sí de la mayoría. Además, es necesario implementar cambios, entre los que se sugieren presentar retos novedosos y diversos.

6 Reconocimientos

Se agradece al equipo del Centro de Desarrollo e Innovación Educativa del Campus Monterrey (CEDDIE) su apoyo y motivación para la elaboración del presente trabajo.

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PAEE/ALE'2018 Submissions for the Students Paper Award

Submissions accepted for the PAEE/ALE'2018 Students Paper Award in English.

The Building of the Leonardo Da Vinci's Self Supporting Bridge using PBL Approach as part of assessment in Mechanics of Rigid Bodies course

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Abstract

The modern engineering professional requires not only technical knowledges but also competences, soft skills and teamwork. PBL approach is being adopted by engineering schools around the world, with the purpose to apply concepts learned in classroom lectures with the professional practices. Seeking to adopt the principles of PBL the professor who teaches the Mechanics of Rigid Bodies course in the Civil Engineering program at Pontifical Catholic University of Sao Paulo proposes the development of a project where the theme was the building of the Da Vinci's Supporting Bridge, as part of the assessment process. This work presents the development of the project. The project was developed in three steps. The first one was a bibliographical survey. The next step was the building of a prototype to analyze the behavior of the structure, force distributions and the application of structural concepts. In the third step the bridge was built in an enlarged size with the appropriate adaptations related to the prototype seeking the fidelization of the original design. Each step with the description of the building and assembly processes were reported in a video available on YouTube.

Keywords: Engineering Design; Project Based Learning; Self Supporting Bridge; Teamwork.

A construção da Ponte Arqueada de Leonardo Da Vinci usando a metodologia PBL como parte do processo de avaliação na disciplina Mecânica dos Corpos Rígidos

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Resumo

O profissional de engenharia moderno requer não só conhecimentos técnicos, mas também competências, habilidades interpessoais e trabalho em equipe. A abordagem PBL está sendo adotada por faculdades de engenharia em todo o mundo, com o objetivo de aplicar os conceitos aprendidos em sala de aula com as práticas profissionais. Buscando adotar os princípios de PBL, o professor que ministra a disciplina de Mecânica de Corpos Rígidos do curso de Engenharia Civil da Pontifícia Universidade Católica de São Paulo propôs o desenvolvimento de um projeto cujo tema foi a A Releitura da Ponte Arqueada de Da Vinci, como parte do processo de avaliação. O projeto foi desenvolvido em três etapas. A primeira foi uma pesquisa bibliográfica. O próximo passo foi a construção de um protótipo para analisar o comportamento da estrutura, a distribuição das cargas e a aplicação de conceitos estruturais. Na terceira etapa, a ponte foi construída em um escala ampliada com as adaptações necessarias relacionadas ao protótipo buscando a fidelização do design original. Cada passo com a descrição dos processos de construção e montagem foi relatado em um vídeo disponível no YouTube.

Palavras-chaves: Aprendizado baseado em projetos; Ponte de autoportante; Trabalho em equipe.

1 Introdução

A utilização de sistemas de ensino baseados em atividades que contrapõem perspectivas teóricas e práticas, tem sido uma ferramenta importante no ramo acadêmico nos últimos anos, sobretudo no que se refere às principais Instituições de Ensino Superior Brasileiras (Santos, 2012).

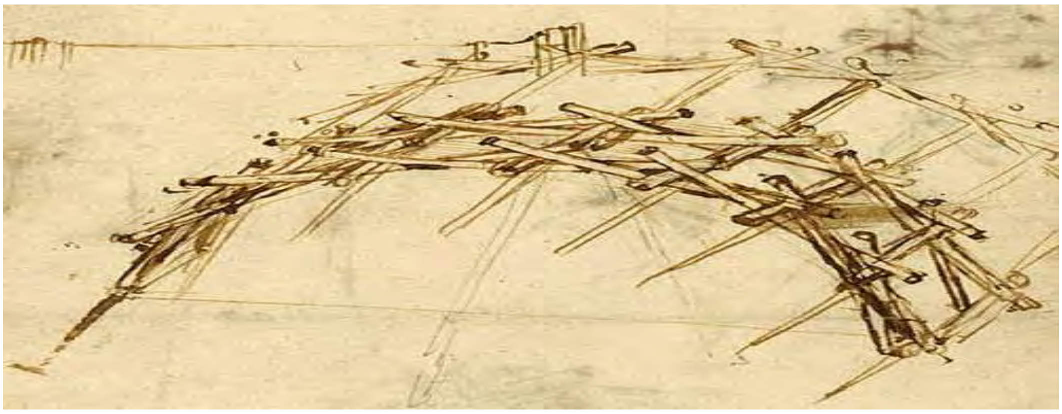
De acordo com Campos et al., (2011) essa abordagem constitui uma ótima ferramenta educacional de ensino/aprendizagem, que desenvolve nos discentes a capacidade de solucionar problemas assim como desenvolver projetos através de aprendizagem auto direcionada, observação, organização, iniciativa e trabalho em equipe.

De maneira complementar, o principal objetivo do estudo da disciplina de mecânica é proporcionar ao Engenheiro os meios que o habilitem para a análise e projeto de variados tipos de estruturas, sujeitas a diferentes carregamentos (Beer, 1994).

Pensando nisso, o professor da disciplina Mecânica dos Corpos Rígidos (MCR), ministrada no quarto período do curso de Engenharia Civil da Pontifícia Universidade Católica de São Paulo, propôs um projeto utilizando-se da metodologia Project/Problem Based Learning (PBL).

O projeto proposto consistiu em uma releitura da Ponte Arqueada de Leonardo da Vinci (Bernardoni, A., Taddei, M., Zanon, E., 2015), projetada em 1520, sendo esta uma das mais simples e engenhosa criações do artista. Utilizando-se de materiais e técnicas simples, a estrutura da ponte tem a capacidade de manter-se estável apenas pelos encaixes de suas barras, sem utilizar amarrações, colas, ou qualquer elemento fixador, recebendo cargas verticais e distribuindo-as uniformemente até os seus apoios.

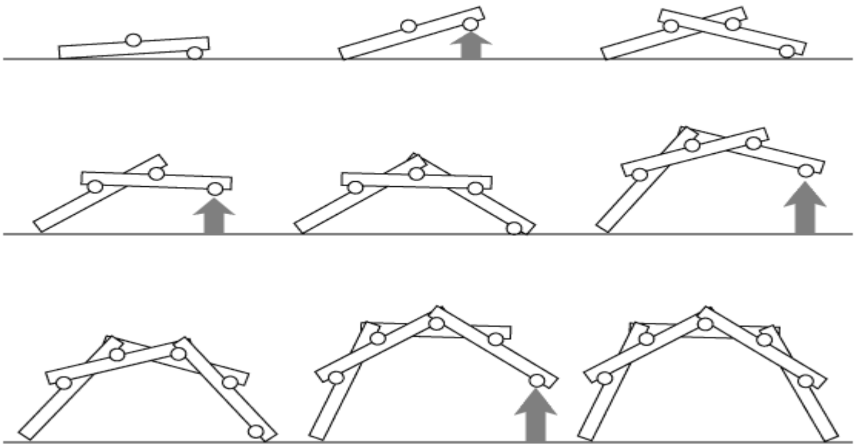
Figura 1. Projeto de Leonardo Da Vinci



Fonte: http://naengenhariablog.blogspot.com.br

O projeto foi desenvolvido em três etapas: a primeira tratou-se de uma pesquisa bibliográfica, onde foram investigadas características tais como a utilização, o funcionamento, os materiais empregados, a geometria, dentre outras. Na etapa seguinte, a montagem de um protótipo que possibilitou a realização de testes e análises para a compreensão do comportamento mecânico da estrutura, além de auxiliar na decisão quanto aos processos empregados para a ponte em escala ampliada, tais como, ferramentas utilizadas, métodos executivos de corte e montagem. Por fim, foi montada a ponte em escala ampliada, com as devidas adaptações para ser suficientemente capaz de suportar além de seu peso próprio, a travessia de pessoas.

Figura 2. Sequência de Montagem

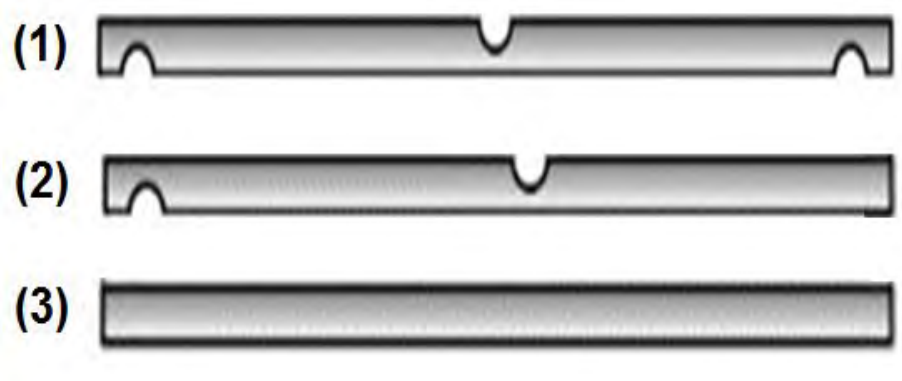


Fonte: http://naengenhariablog.blogspot.com.br

A busca pela fidelidade ao projeto original de Leonardo da Vinci foi a principal motivação do grupo, sobretudo no que tange o formato das peças que compõem a estrutura. A ponte é composta por barras roliças de eucalipto com sulcos dispostos ao longo de sua extensão de forma a garantir que o simples inter-travamento das barras seja capaz e suficiente para garantir a estática da estrutura, dispensando a necessidade de utilização de qualquer elemento fixador.

Para o perfeito encaixe foi necessário criar três tipos de barras: (1) com três sulcos, sendo um centralizado e dois nas extremidades em posições opostas ao do centro; (2) com dois sulcos sendo um centralizado e um na extremidade em posição oposta ao do centro; (3) inteira sem sulcos (Figura 3).

Figura 3. Tipos de barras



Fonte: Autoria Própria

Um aspecto muito peculiar da ponte arqueada de Leonardo Da Vinci é a simplicidade do material e das técnicas empregadas na sua construção, sendo que o único material utilizado para a execução foram pontaletes roliços de eucalipto. Quanto às técnicas, estas foram determinantes para o resultado obtido, pois através apenas de cortes e encaixes conseguiu-se construir um elemento com grande resistência e versatilidade.

Para obter o encaixe perfeito entre os pontaletes roliços foi necessário que os sulcos fossem realizados com muita precisão e uniformidade, para isso, utilizou-se uma serra-copo acoplada a uma furadeira de bancada cujo diâmetro era equivalente ao diâmetro dos pontaletes (Figura 4).

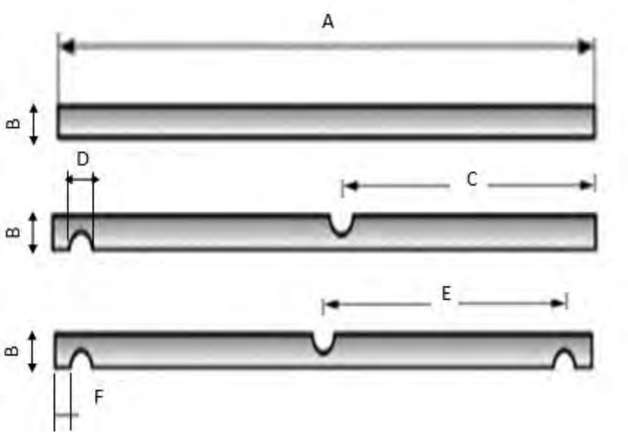
Figura 4. Preparação dos pontaletes pelos alunos na oficina

Fonte: Autoria própria

O dimensionamento do protótipo foi realizado de maneira arbitrária, pois não foram identificados registros de medidas do projeto desenvolvido por Da Vinci. Quanto à ponte em escala ampliada, esta foi dimensionada de acordo com a necessidade de suportar o seu peso e a travessia de pessoas e com os resultados obtidos no ensaio realizado com o protótipo até a sua ruptura. Na Figura 5 e Tabela 1, estão explicitadas as dimensões do protótipo e da ponte em escala ampliada.

Figura 5. Dimensionamento das barras

Tabela 1. Dimensionamento das barras



	PROTÓTIPO	ESCALA AMPLIADA
A	250mm	120cm
B	16mm	8,5cm
C	125mm	60cm
D	15mm	9cm
E	95mm	45,5cm
F	25mm	10cm

Fonte: Autoria própria

Após a execução e a apresentação do projeto, a ponte construída passou a fazer parte integrante dos Jardins Burle Marx, no Campus Marquês de Paranaguá da PUC-SP (Figura 6). Além disso, o grupo foi convidado a realizar uma gincana durante a semana de acolhida aos novos calouros e durante a semana acadêmica, a fim de motivar os demais estudantes a desenvolverem atividades baseadas na Metodologia PBL.

Figura 6: Versão final do protótipo e da ponte em escala ampliada e a equipe de trabalho

Fonte: Autoria Própria

2 Atividades a serem desenvolvidas durante o evento

Utilizando-se de recursos expositivos visuais tais como um vídeo, banner e protótipo, além da exposição oral do projeto, buscar-se-á que o público presente à exposição do trabalho consiga, através da organização em grupos e tomada de decisões, a montagem de um protótipo fiel ao projeto de Da Vinci.

Haverá a exposição completa da composição do projeto e a explicação dos métodos, características e objetivos para a execução da atividade. Por meio de uma competição entre equipes, avaliando-se o tempo e qualidade de montagem, os grupos deverão escolher a quantidade e modelos de barras adequadas para a estrutura, as quais estarão agrupadas em caixas de acordo com suas características (quantidade de sulcos) e então iniciam a montagem com acesso apenas as informações visuais, sem qualquer consulta aos expositores.

Após a conclusão será feita uma avaliação da qualidade e fidelidade da montagem de cada grupo, observando se foram respeitadas as especificações de: 18 barras em 6 módulos; a não utilização de peças alheias à estrutura e a estabilidade desta. Terminada a atividade será aberto um espaço para discussões sobre a aprendizagem obtida e as dificuldades encontradas.

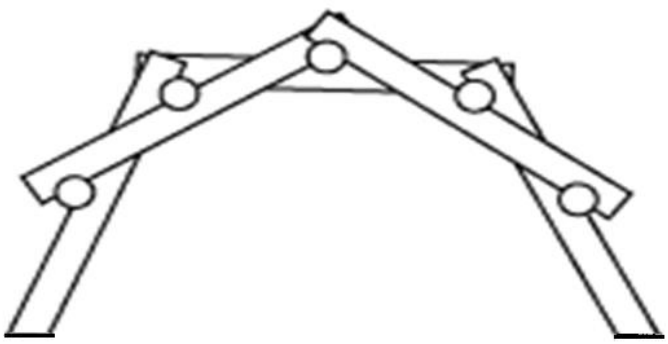
3 Conclusões

Os participantes tiveram, a partir da experiência realizada, a oportunidade de analisar/refletir/implementar a utilização da abordagem PBL, com ganhos significativos na aprendizagem uma vez que ao analisar o comportamento estrutural da ponte arqueada o estudo da disciplina Mecânica dos Corpos Rígidos demontrou sua fundamental importância através dos conceitos da disciplina onde alguns dos desafios encontrados foram superados, proporcionando maior eficiência ao projeto final.

Inicialmente quando submetida à uma força descendente a distribuição dos esforços transmitidos às peças intertravadas provocava um deslocamento uniforme das peças da base e, por conseguinte, uma redução do arqueamento da estrutura. Desta forma, a estrutura demonstrava não estar em equilíbrio porque a resultante da força descendente não era equivalente ao binário gerado pelas reações de apoio. Atrelado a este fator existia ainda o agravante da superfície de contato dos pés da ponte não serem suficientemente eficientes, requerindo, por conseguinte, melhoria destes dois aspectos.

Para tanto, foram realizados chanfros nas peças que compunham a base da ponte, aumentando assim a superfície de contato entre a estrutura e o solo onde a ponte seria apoiada. Para resolver este problema, de maneira complementar, foram fixadas bases de material polimérico a fim de aumentar o atrito entre a base da ponte e o solo, atenuando assim o intertravamento das peças provocado pelos encaixes côncavos; a estabilidade destes encaixes devido ao atrito existente entre as peças intertravadas; e o equilíbrio da estrutura arqueada autoportante como um todo.

Figura 7: Detalhe dos chanfros nas peças



Fonte: Autoria própria

Isto posto, desenvolveu-se a capacidade de visualização de configurações físicas levando em consideração as restrições reais proporcionando a experiência de identificação e análise dos problemas enfrentados na execução do projeto e como solucioná-los com os conceitos adquiridos no decorrer dos quatro semestres de graduação em Engenharia Civil, sobretudo no que diz respeito a disciplina de Mecânica dos Corpos Rígidos demonstrando a coesão existente entre o pequeno número de ideias fundamentais e a grande variedade de problemas que estas ideias podem resolver.

Além disso, pode-se dimensionar a importância da aplicação da Metodologia PBL como uma ferramenta de aprendizagem ativa, buscando na sua implementação mudanças pedagógicas que aprimoram e desenvolvem competências e habilidades para a solução de problemas ou execução de projetos, que certamente serão enfrentados na futura vida profissional.

As competências de relacionamento interpessoal que desenvolvemos e o trabalho em equipe com divisão de responsabilidades e a confiança adquirida nos componentes do grupo serão importantes para a nossa formação e vida profissional futura. A fim de demonstrar a experiência que cada estudante teve, foi elaborada uma sessão de depoimentos e aspectos complementares que está disponível no seguinte endereço eletrônico: https://www.youtube.com/watch?v=issE7-XHBgo .

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Active learning with practical engineering applications through the LAICAnSat project

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Abstract

The LAICAnSat project was created in 2013 by the Laboratório de Aplicação e Inovação em Ciência Aeroespacial (LAICA) of the University of Brasília (UnB) and its purpose is to design, build, test and launch a stratospheric balloon using a low cost technological platform with several scientific applications. It's developed by 13 students from different areas of engineering, such as aerospace, electrical and mechanical. The multidisciplinary activities are aligned to academic studies and integrated to processes related to projects. The structural designing of the LAICAnSat's platform is a great chance to apply active learning in aerospace engineering, with application of the basic characteristics of an aerospace mission, such as cost management, mass and size limitations, sustainability and considerations of international standards. This platform was developed according to the 3U CubeSat and PC/104 standards. The international CubeSat standard goal is to design small satellites, and by following it, this allows the LAICAnSat project to be a modular platform used as a mechanism that emulates a great variety of missions. On the other hand, the international standard PC/104 allows the LAICAnSat to accommodate compatible electronic systems, such as embedded computers, according to the market availability. The opportunity to employ non-conventional fabrication processes, such as 3D printing, permits learning the behavior of materials and understanding the importance of every piece in the platform. The launch is one of the most complex part in the entire project and brings a great amount of knowledge to every member. In this stage the engineering students are faced with problems that require simple and immediate solutions for the mission success. The Kuaray mission is a partnership between the LAICAnSat Project and CAsB (Clube de Astronomia de Brasília) and its main objective is to film in 360°, from the stratosphere, the solar eclipse that occurred in August 21th, 2017. This accomplishment happend thanks to the University of Montana that invited the LAICAnSat Project to participate with them on the NASA Space Ballooning Project. From a questionnaire made with the students involved, was verified a good degree of satisfaction with the learning and development of the project, demonstrating, in its great majority, motivation to participate in new missions.

Keywords: Problem Based Learning (PBL); Active learning; LAICAnSat; CubeSat; Solar eclipse in 360°.

1 Introduction

The LAICAnSat Project, from the University of Brasilia, began in 2013 and its main objective is to prepare the students to work in the aerospace field and to capacitate them to deal with the difficulties in a space mission. The project consists of different types of students, in different engineering courses in theirs own semesters, resulting in more than 10 students participating in undergraduation in aerospace, mechatronics and electrical engineering.

LAICAnSat's platform is based on CubeSats, that is a nanosatellite which size is predetermined in 10x10x10 cm, because of the required space missions of LAICAnSat. It is built in variations of the CubeSat standards, which is 2U and 3U. This platform is also very useful in preparing the students to work with this promising and contemporaneous satellite due to its low weight and low price of the launch. The launch of the LAICAnSat's platform is done by a meteorological balloon, helium inflated which makes mission safer.

In order to be more efficient, the project is divided in different fields, such as structure, electronics and payload. The first one is based in the CubeSat standard and it is printed using PLA. These points are responsible for the low price and weight. The second, develops the motherboard that is responsible for obtaining atmospheric and payload's data, for example. The last one is where the cameras are, which will capture images of the flight.

Felder (2006) emphasizes that it is of the importance that the engineer knows how to work in group. This characteristic must be shaped through practical learning of common situations in the industry, such as facing problems in which the response time and costs are very important to be considered.

For Prince (2004) active learning can be defined "as any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing". This concept is difficult to apply in the classroom due the nineteenth century teaching methodology that is known for its inflexibility or, as defined by Aquino (1998), the disinterest of the student and teachers themselves.

In this way, the best way to apply active learning methodologies it's in a project because this one makes the future engineer works in different areas that require rapid and complex decisions, which adaptability and teamwork are important demands.

The project develops instinctively following the four steps of Didactical Engineering cited by Canu (2016). The steps are shown below and are remarkably recurrent during this article.

- A preliminary analysis investigating the epistemological, cognitive and institutional conditions and constraints;

- A design and a priori analysis with particular attention paid to the identification and selection of values for the didactic variables and anticipation of their potential effect on the "students-milieu2" interaction;

- An experimentation;

- And a posteriori analysis and validation of the hypotheses underlying the design.

This project gives the engineering students a great opportunity to a real-life demonstration of an aerospace mission and for preparing them for the difficulties of working as a group. They come from different areas of this field such as Aerospace, Mechatronics and Electronic Engineering.

2 Structure

The structural project of the LAICAnSat's platform is a great tool for learning and applying knowledge in aerospace engineering. In all aerospace projects, the platform has some parts of specialized research with concepts in Materials Science, Solid Mechanics, Materials Resistance, Structural Mechanics and Structural Dynamics. Besides these areas, Analysis of Structural Projects, Static and Dynamic Studies of Finite Elements and Application of Modeling and Simulation Environments/Softwares (CAE, CAD and CAM) complement the professional and future formation of the student, part of this group of research.

During the entire project's fabrication, the students involved have the opportunity to work and learn about all the steps of creating the platform, beginning with the brainstorm and the preliminary ideas, through the execution, modeling and prototyping steps until the last one, which is the conclusion and delivery of the product. Each one of these phases have development methodologies and follow standards that get together the rules and specifications in the job market. The goal is to develop professional profiles that will attend the market needs.

2.1 Standard

According to Dayrell (2017), the companies sense the consequences of the lack of standards in theirs everyday activities when they are frightened with a competitive market.

Regarding to the rules and standards, structurally, the LAICAnSat's platform was develop according to the CubeSat and PC/104 standards. The consequences of this choice are the reduction of the working variability processes.

The CubeSat's normalization is an international standard of small satellites for the purpose of reducing costs and increasing access to the space. In 1999, the CubeSat Program of California Polytechnic State University began. The CubeSat standard is a worldwide benchmark in a satellites development and commercial standard for the creation of space subsystems.

This pattern was chosen because of its modular character, which makes it quite versatile for the final objectives of the LAICAnSat project as a research platform. Normally, the regular standard has a working unit, known as 1U CubeSat, that is a nominal 10cm edge cube and a 1.33kg boundary mass (Puig-Suari, 2014).

According to Figure 1, externally, in a simpler model, a 1U CubeSat can be composed of Deployment Switches, Rails (or External Support Interface), Access Ports, Top Protection Walls, Base and Sides. According to the number of available work units, there are variations of the regular pattern.

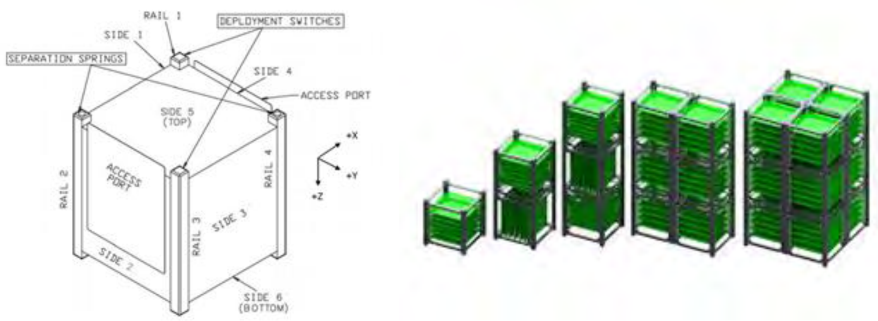

Fig. 1. 1U CubeSat. (Source: Puig-Suari, 2014, p. 18.) (right) and CubeSat standart and its variations. From left to right follows the 1U, 2U, 3U, 6U and 12U versions. Source: Radius Space. (left)

The 3U CubeSat is a variation of the conventional standard. It has three vertical work units and nominal size of 10x10x30cm, reaching a total mass less than 4.0kg.

The choice of the 3U CubeSat standard was due to the platform internal space management with the objective to accommodate compatible electronic boards according to PC/104 specifications (standard for embedded systems, chosen according to the needs of the Electronic System research group) and also a parachute with the shape of a paraglider and possible payloads.

The PC/104 standard is the differential of the platform embedded systems. If followed, the LAICAnSat platform is able to receive various types of devices and equipment available in the market without the need to operate unplanned modifications to the platform accommodation.

2.2 Modelling

Choosing the 3U CubeSat standard for LAICAnSAT's platform, the structure modeling has the objective to provide a three-dimensional representation of the project. In the phase, leads to the necessary knowledge to design, test, operate, simulate and understand the operation of the platform in all its complexity and systems.

After identifying the structural pattern and all the subsystems that make part of the platform, the project modeling begins. The initial phase is focused on the development of external structure and the mechanisms of the internals support. The second one provides the subsystems modeling. The third and last phase is the assembly of all the platform parts. The modeling was done using CATIA V5R19, software from Dassault Systems for 3D drawing, widely used in the aeronautical and aerospace industry, capable of integrating with other software/tools of 3D modeling and 3D simulation.

Structurally, LAICAnSat is resumed to mountable modules in the form of cast section cubes with interconnected internal supports, individually designed according to their function and constraints, and joined together by bolts and nuts. There are three work units, inferior, central and superior modules, enabled, respectively, for the insertion of payloads; data processing, energy and communication systems; and flight.

The three-dimensional modeling take place along with the activities developed in the research group of 3D Printer manufacturing of the LAICAnSat project. From this group, functional requirements, such as, minimum wall thickness of the modules, need some modeling adjustments so the structure would withstand the mechanical stresses requested by the mission and guarantee the required conditions of reliability of proposed resistance.

The walls initially designed had dimensions of 3mm thick, which, according to the tests, would be sufficient to attend the demand of the mission, as long as the direction of printing was vertical. However, after observations and tests, it was found that, due the obtained modeling of the structure, there was still a thin wall of 1.5 mm that formed along two sides of the external supports due to the compliance they had with the regular 3U CubeSat standard and internal board PC/104 simultaneously. In order to do so, without prejudice to the detriment of any of these standards, this situation was solved by using smoothing techniques of the internal board and also took advantage of the exceptions in the specifications of the standard, which allow a lateral increase of up to 6,5mm normal the surfaces indicated in yellow in Figure 3. (Puig-Suari, 2014).

The first version of the structure has 106,5x106,5x340,6mm as dimensions and an estimated mass less than 4kg. With this dimensional tolerance the modeled structure fulfills resistance requirements and recommendations obtained in static testing guided by the group of 3D Printer Manufacturing. This structure can be seen in Figure 2.

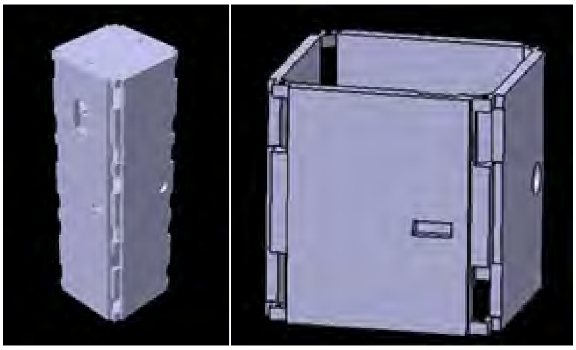

Fig. 2. CAD of the complete structure version 1 (left) and central module (right). Source: Made by the Author.

With version 1 finished, it was sought to optimize the structural design from the observations made during the assembly phase of the platform. The assembly process until then was given serially, each component, from the inferior module to the superior module, coupled to the structure one at time.

For version 2, was proposed a structure with greater ease and ergonomics of the assembly, generating a fluidity handling and intuition during the operational process. The solution was based on the idea of assembling the entire internal structure of the platform first, and then placing it in the modules. The replanning of the structure (version 2) consisted of dividing each module in half and thus obtaining a total of 6 half-modules, this configuration is shown in Figure 3.

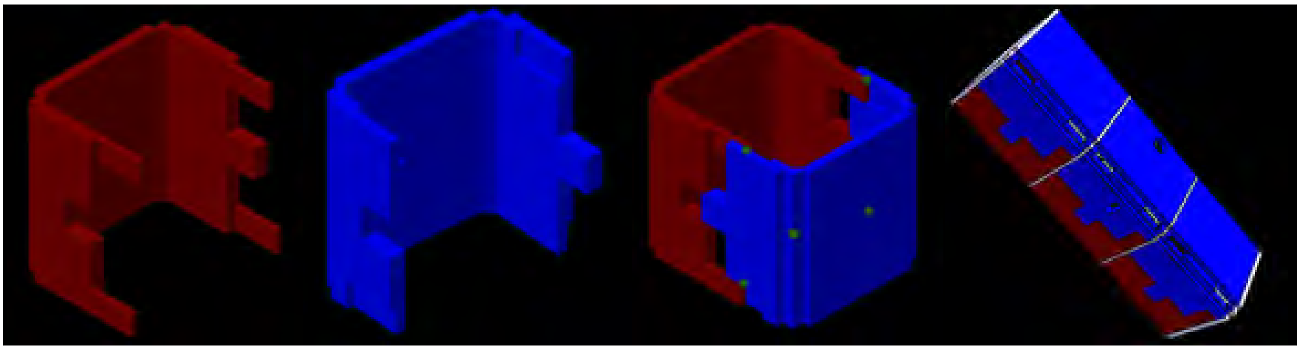

Fig. 3. CAD module of the structure version 2. Mountable module 1 (first, left) mountable module 2 (second), junction of mountable modules (third) and complete CAD (fourth). Source: Made by the Author.

The structural alterations that had as objective the ergonomic and mass optimization of the platform, the last version developed and proposed differs from the others because it has a mass-system assembly with a 50% lower weight. In addition, version 3 has sides with easy-access openings according to the need to activate electronic systems immediately and the execution of other manual processes that required direct contact with the embedded systems or payloads at any during the launch phase. The structure of version 3 can be seen in Figure 4.

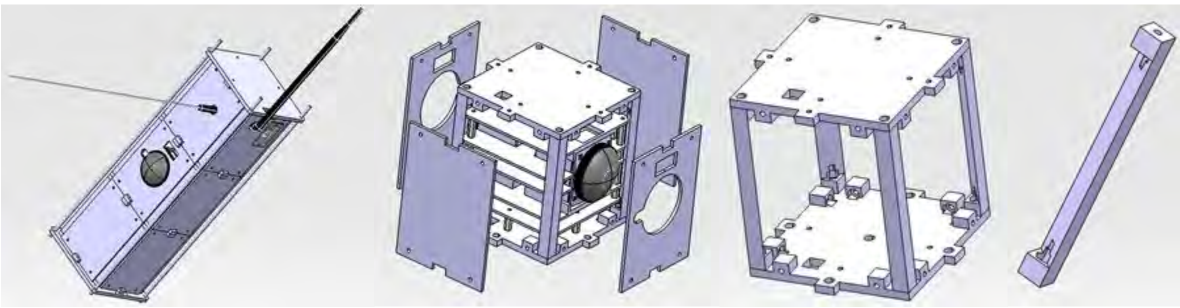

Fig. 4. Full CAD of Structure version 3 (first, left) module in expanded view (second) and Structural Members subject loads application (third and fourth). Source: Made by the Author.

It is also noticed that in this new proposal, the loads imposed on the platform are destined solely and exclusively to structural members designed for this purpose, while the others, for not have any mechanical demands, are structural members with only aesthetic objectives, an essential requirement in the development of an engineering product in the eyes of a competitive market.

2.3 Manufacture

The printing of LAICAnSat's structure uses a3D printing technique called Fused Deposition Modeling (FDM). The extruder nozzle is heated to melt the material where it moves on three axes (XYZ), controlled by Computer Aided Manufacturing (CAM) software. Then, a thermoplastic filament is unwound and brought to the nozzle extruder, controlling its melting and deposition of the material flow, resulting in several layers that are hardened almost immediately after their extrusion. This process occurs based on the CAD drawing of the parts, these are converted to STereoLithography (STL) file format supported by the 3D printer.

The LAICAnSat's team performed tests of printed parts with the two methods cited and those printed vertically presented better mechanical resistance, being chosen as the printing standard to attend the requirements of launch, flight and landing efforts. The last fabricated structure can be seen in Figure 5.

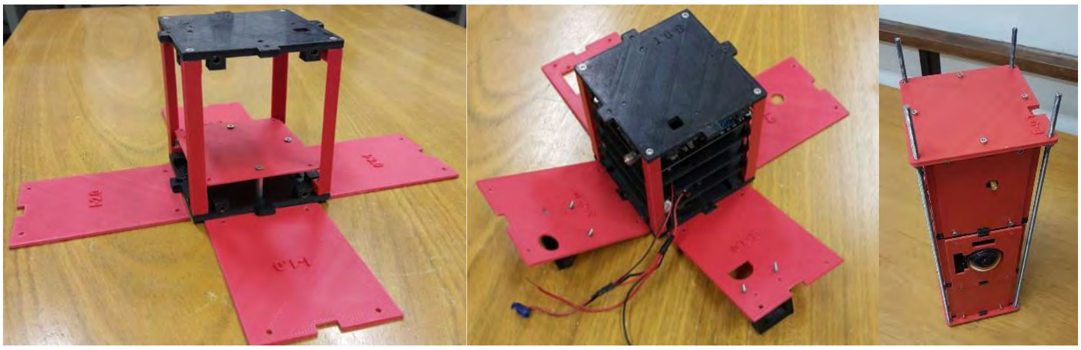

Fig. 5. Module without the inner stages (left). Module with the internal stages positioned (middle) and complete structure mounted (right).

2.4 Material

The project uses 3D printer to make a prototype and the final manufacturing of all structural pieces. This process allows the use of alternative polymeric materials like PLA, PEEK, ABS, PET-G and Nylon. The choice of among those ones, used in LAICAnSat's platform, is a direct application of concepts resistance of the materials and optimization.

The material chosen for the structure was PLA (Polylactic acid). This polymer attends the structural requirements, such as low price, reliability and easy manufacturing. All the considerations to choose the material was focused in real engineering projects.

3 Launch

The LAICAnSat project has 5 launches in total. Since the first launch was noted the need to create a launch procedures standard and some documentation to record the entire process and data of each flight. This kind of information is studied, such as technical and scientifically reports, to improve the launch efficiency.

The launch is one of the critical points of the project because several activities must be coordinated and made accurately at the same time during the given timeframe. Consequently, NASA methods of organization and check list of a launch are used. This step takes a lot of teamwork, as can be seen in Figure 6.

Fig 6. Assembly of the structure (Background), filling of the balloon (In front).

The members are divided into groups that work in different phases, as shown in Figure 7. Each one of them faces different situations and problems. For example, super superheated cameras, stage (2) in Figure 7, calculation of the cylinder flow from the balloon to fill within the estimated time, stage (3), better positioning the antennas to receive the telemetry, stage (1). Therefore, each member must work together to present the best solution in the shortest time, being the moment in which all theoretical knowledge is put into practice, evaluating the speed of response and efficiency of the engineering student.

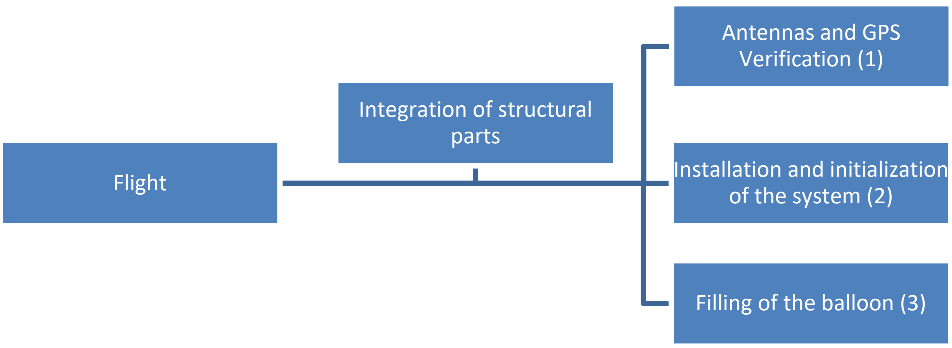

Fig. 7. Launch phases.

4 Kuaray Mission

The Kuaray mission is a partnership between the LAICAnSat Project and CAsB (Clube de Astronomia de Brasília) and its main objective is to film in 360°, from the stratosphere, the solar eclipse on August 21th, 2017. This was a great opportunity because this event is very rare. One similar happened 99 years ago in the Northern Hemisphere. Now, with the accomplishment of the mission, a lot of people can see this eclipse on a 360°

perspective, thanks to video that the project made. In Figure 8 is possible to see details before and after the eclipse through one of the boarded cameras.

Fig. 8. Minutes before the eclipse (left) and during its totality (right).

This astronomical event, in 2017, was visible in its totality only in the United States and the team went there to ensure our mission. It was the fifth launch of the project and the payload, the LAICAnSat-5, was attached on the payload of the University of Montana's balloon. This accomplishment happened thanks to the University of Montana that invited the LAICAnSat's team to participate with them on the NASA Space Ballooning Project. The project was the only foreigner team that was invited to this event and more 60 others colleges and universities were involved. With this opportunity the LAICAnSat team gained different experiences that will help the improvement and decide the future of the project.

5 Student Learning Assessment

LAICAnSat is composed of several missions, where each mission considers a new objective in which students must study past missions, considering errors and correctness, and developing or improving solutions. After the end of the last mission, a questionnaire was done by the students involved to verify the learning and satisfaction with the project. The results obtained are discussed below.

In Figure 9 it is questioned if the project met the initial expectations about the learning, working in group and contribution to the engineer formation, applications submitted in the proposal of ingress to the team. It is emphasized that 1 indicates that it was not satisfied at all and 5 completely fulfilled the expectations.

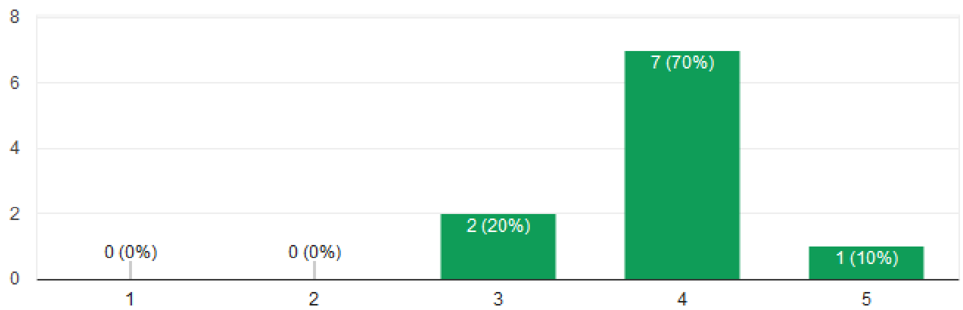

Fig. 9. Evaluation to verify if the initial expectations were met.

Figure 10 shows the degree of satisfaction with the group of students working together. It is noteworthy that the group is formed by students of different engineering.

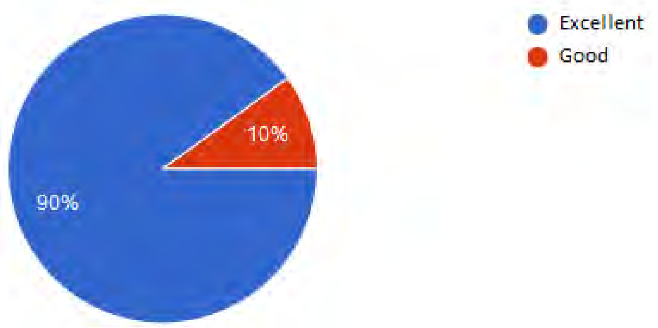

Fig. 10. Evaluation of the degree of satisfaction with the group of students of the project.

In relation to the degree of experience gained and the practical knowledge applied, the results obtained with the questionnaire showed that 90% of the students are satisfied with the experiences and knowledge acquired.

Therefore, the opportunity to work at the LAICAnSat's project was exceptional because it allowed practical experiences during the undergraduate process, by applying, in a technical way, theoretical ideas and concepts acquired in disciplines of the University, in the elaboration of solutions needed in the project.

6 Conclusion

This article has the objective to present the experience in the development of the LAICAnSat platform. The members are intended to design, build, test and launch a stratospheric balloon using this low-cost technology platform. The structural project is integrated with standards, manufacturing and material in order to develop a project with applications in the engineering area.

In addition, experience of the five launches of the platform, from the first to the last one has been recorded. One of the major points of the Project is the moment of launch because its requires the verification of antennas, initialization of the system and filling of the balloon.

Therefore, the lessons learned in the Project can be divided into 3 crucial points. First, discussions, sharing knowledge from various areas, such as, Aerospace, Mechatronics, Electrical, Electronic Systems and Automation. Second, synthesis, solutions proposals are organized by each area in a collaborative way, allowing integrated solutions for the Project. Third, viability, the study of the technical viability of the project, showing all the solutions for the development of the platform.

Due to the search of solutions for the standards integration problems, combined with the platform modular nature, it is noticed that the design obtained in the LAICAnSat platform is a flexible, compact, light and resistant, structure that operates in the most varied types of mission. It can also shape itself according to the respective integrated payloads. Besides, it can provide the basic technical and theoretical knowledge for the student's improvement, reinforcing the idea of the active learning of the structural requirements engineering.

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Practical application of classroom theory through participation in aerodesign team

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Abstract

The Mamutes do Cerrado Aerodesign is a competition team that is formed by students of different engineering courses. The team was founded at the University of Brasília (UnB) in 2015 with the main objective to foment the students` interest in the aeronautic subjects, applying their technical knowledge in practical engineering projects. To guarantee the learning quality, for each new member basic knowledge about aircrafts is taught, and after that his or her profile is identified he or she is forwarded to a specific area to increase his or her knowledge. And then, members join the final assembly aiming to keep knowledge. By being an extracurricular activity members are exposed to management and project issues, such as cost and time handling, this is a big example of extracurricular "Hands-on. Rarely a discipline will have methodology teaching and evaluation as close to the real situations of society and the job market as that found in a competition team. From preliminary studies until the aircraft analysis with the complete model, the team employs a variety of engineering software to determine some parameters and consult several bibliographies to make calculations according to the theory. In this way, the results are compared to the theory. The whole project is an unprecedented challenge, once it is required that the aircraft can carry 4 kg of a LAPES (Low Altitude Parachute Extraction System) payload and has a transport box with a maximum volume of 0.1 m^3. Through the practical applications of the problem based learning, the competition between teams and the real development of an aeronautical project. Consequently, the team has sought solutions to problems of multidisciplinary optimization, besides the development of new manufacturing procedures and use of non-conventional materials.

Keywords: Mamutes do Cerrado, AeroDesign; Problem Based Learning; Active Learning; Competition Team; SAE Competition.

1 Introduction

The Mamutes do Cerrado is competition team of the Aerospace Engineering course by the University of Brasilia, the team was created in 2015, and it seeks to introduce the undergraduate students into environment of engineering real problems (Shynkarenko, 2017). Aerodesign projects are done since the concept until the building, they are based on some requirements of SAE Brasil Aerodesign, acronym to Society of Automotive Engineers Brasil Aerodesign, that is an international institution, considered one of the main sources of automotive and aerospace patterns and norms in the world (SAE). In Brasil SAE is responsible for many engineering competitions that can take latin american teams to compete on international level, among these competitions, it can be found SAE Brasil Aerodesign, which is the one that Mamutes do Cerrado is a competitor (Cerrado, 2016).

To Canu (2016) Hands-on "activities are considered to develop a deeper kind of knowledge as well as links between theory and practice", the best way to do this link is having a competition team in reason of the multidisciplinar demand of the contents that have been given in the classroom or the contents that were not learned in the classroom.

Prince (2004) define active learning "as any instructional method that engages students in the learning process. In short, active learning requires students to do meaningful learning activities and think about what they are doing". A competition team rises primordial characteristics to achieve learning by its huge need of engineering applications, with the domain of the actions.

To accomplish an effective learning, it has been developed a methodology, which makes the knowledge sharing among the members of the team easier. This methodology calls "METODOLOGY OF MAMUTES". After the conclusion of the selective process, classes were taught to the new members with the aim of teaching them the basic knowledge about airplanes working, afterwards there were activities to be done by the new members and books to be read, so that they could study alone on vacation. For each area of the team, there were a manager, this manager supervised the on going of the study process, and he/she was able to answer to any doubts. After 2 months there were the specific classes to each area, that are: Managerial, Marketing, Development, Loads and Aeroelasticity, Stability and Control, Electronic, Structure and Structural Testing, Aerodynamic, Technical Design and also the Young Mamutes. The area Young Mamutes will have classes about all the areas.

In the specific classes beyond the specific knowledge the starting members learn how they can apply this knowledge in to an aerodesign project. After finishing the classes, reports that justify the choice that the starting member has done, to which area he/she chose to work in, and then they were instructed to build the prototype of the aerodesign competition with the older members.

Besides the learning that might boost the initial member and his/her knowledge in the job market, the team also works with a social view, social visits in public schools are made to teach the students the basic concepts of aeronautics, and how is the Aerospace Engineering course of the University of Brasilia, and how they can apply to attend this course, this is done by speeches. The main aim of this is to spread the aerospace culture and teach the basic concepts that the Mamutes team have learned working with the team.

The SAE Aerodesign competition began in 1986 in United State, the partition in Brazil began in 1999 and grow every year. The competition objective are promote the culture and aeronautic learning, develop teamwork, leadership capability and professionalism.
The competition consist of a undergraduate students doing a aerodesign project with objective to do a mission, this mission changes every year, forcing the participants to innovate and do new project. In this way the SAE competition philosophy is to promote a better professional qualification through the technical area, organizational aspects and teamwork. Target Stakeholders

2 Project Development

The team sought a methodology to the better performance of the project according to financial constraints and the time of the group. Then the methodology was divided into five steps which, were exactly followed in the development of the project.

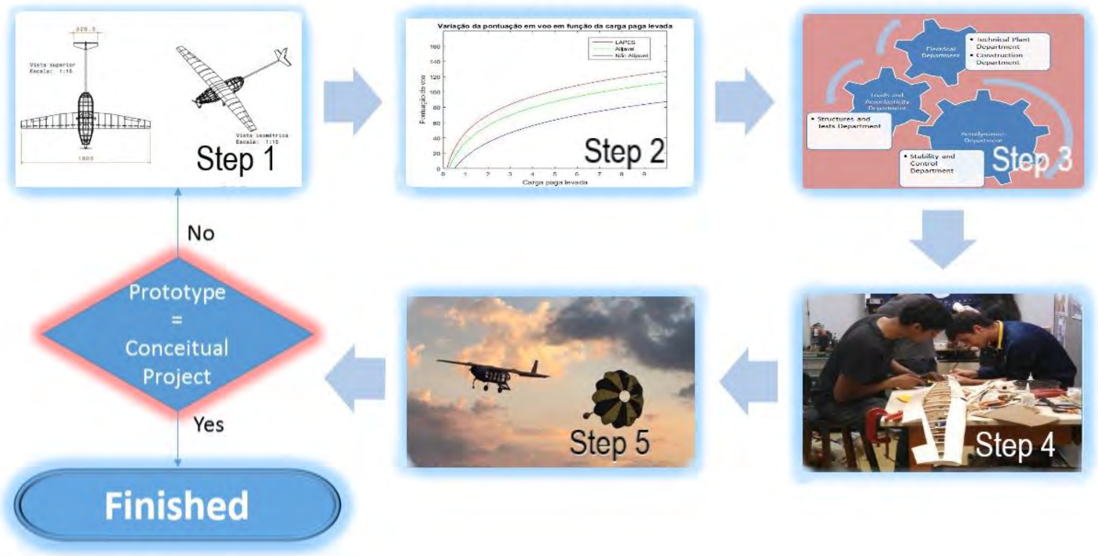

Figure 1. The steps for development of the project.

The first step was the conceptual project, where there were the study and delimit of aircraft's features in according to SAE Brazil regulation, which includes a transport box with an intern volume of 0.1 [m^3] and electric propulsion. Other considerations have been taken due to the past experiences at previous competitions, such as tricycle landing gear, high wing, a wingspan between 1.8 and 2.0 [m], root chord around 0.2 and 0.3 [m] and tip chord about 0.09 and 0.1 [m].The second step was to formulate an equation of maximum score of flying with payload and maximum empty weight estimated of aircraft.

The third step was the division in areas, such as Aerodynamics Department, Stability and Control Department, Loads and Aeroelasticity Department, Structures and Tests Department, Electrical Department, Technical Plant Department and Construction Department.

The fourth step was the tests and fabrication, where there were tests, simulations, choices of materials for each component designed and developed from each area of the group. In the end, there was an optimization of such design.

The fifth step was the analysis between prototype and theoretical project, where if there are some big differences, there is the necessity to back to the first step, the conceptual project.

During the development of the project it was necessary to use all the theory learnt in classes, however in a different way. The distribution of lift, the exact bending of structural elements the optimize tail volume and other analysis should be determined not only in specific points and the accurate results must be used.

In order to save time and money the team decided to use several softwares to understand better the phenomena and then take important project decisions, based on the outcomes given by these tools.

Firstly, the team became familiar with the topic and after understanding the theory behind certain analysis we decided to learn how to use the software. This steps are very important and cannot be neglected, because the wrong use of the software may deceive the team to make some mistakes, which can compromise all the project.

There is a great relevance of getting acquainted with these tools during the undergraduate course, because the companies develop their projects using a similar methodology which is being used inside the team and it is a great advantage, even for the academic part, because once the knowledge acquired may be an important mechanism to be taught.

3 Practical Applications of Classroom Content

The project for the SAE Brazil AeroDesign Competition is, first above all, an aeronautical project that aims to simulate an engineering project for the market, so it is based on scientific knowledge by its members. The competition is open to students of engineering related to mobility to contribute to their formation, offering the opportunity to work as a team, manage a project and mainly apply the knowledge acquired during graduation.

The Mamutes do Cerrado Project for the competition in 2017 consisted of the following stages, theoretical design, project detailing and reporting, construction and testing. In each of these stages it was possible to apply the knowledge learned during the graduation of the students involved.

3.1 Theoretical conception

During the theoretical design of the project an analysis is made of the competition rules and some fundamental decisions are made that are the starting point of the project. The main choices made were the type of load we would carry from an optimization of the factors of the score equation, comparison between types of payload is seen in Figure 2, and the other choice was a load factor greater than the last Project. For such design decisions, were applied basic aerodynamic knowledge obtained through the disciplines of courses such as Aerospace Systems and Aerodynamics of Aerospace Systems. Already the optimizations were calculated and implemented in MATLAB which is a direct application of the knowledge acquired in mathematical subjects such as Calculus and Numerical Methods.

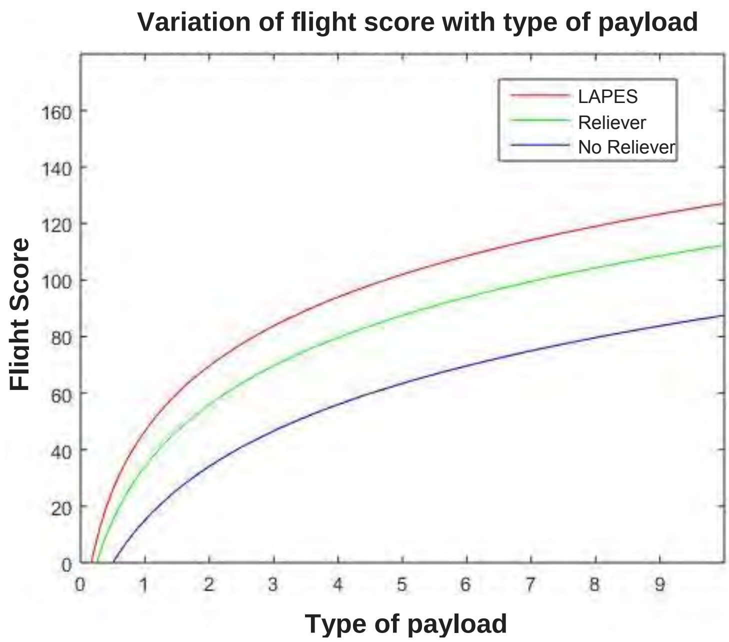

Figure 2. Graphic used for optimum load selection

3.2 Project detailing and report

As part of the SAE AeroDesign 2017 evaluation, a report on the project is required. After the initial theoretical conception it is in this stage that the project took shape, and began to be detailed according to Sandraey (2012).

For the design of the wing and tail of the aircraft all the theoretical referential seen in the room of the disciplines of Aerodynamics of Aerospace Systems and Flight Mechanics were used in conjunction with the existing literature. In this phase of the project were chosen, for example, the airfoil design and the optimum size of the tail arm of the aircraft as a result of applying knowledge about aerodynamics in an optimization made in mathematical software.

For structural team the knowledge about of Solid Mechanics and Materials Science is indispensable and that are basic subjects of the Engineering course, but already for the production of the report, the analysis of the structure chosen in finite elements (figure 3) is important to justify the decisions of the team. The choice of materials for this year's project is the result of experiences in disciplines about Composite Materials and Plastics and Manufacturing Technologies, research projects and internship of team members.

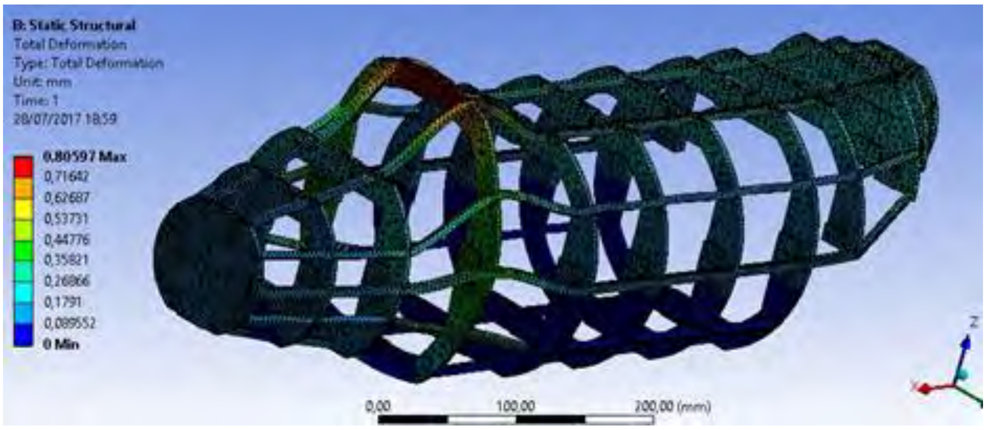

Figure 3. Stress analysis with structural software.

The analyses made by the areas of Performance and Electronics and Stability are direct application of knowledge obtained in the area of digital electronics, electronic circuits, aerospace systems and systems control and numerical methods during graduation in the theory of aeronautical projects, all analyses and tests performed about the aircraft's behaviour are to justify and support the choices made and go to the report.

3.3 Construction and testing

In the final phase of the project, not only is it necessary to have the manual skill for the service, but also the knowledge about the materials, the manufacturing processes involved, which are experiences and knowledge obtained for example in disciplines such as Experimental Methods and Manufacturing Technologies. Already the methodology of work and quality management as well the safety of those involved are also indispensable for any project that produces something. Due to this in the graduation of the course of Aerospace Engineering the disciplines of Production Management and Quality and Safety of work are part of the compulsory curriculum of the course. The first prototype is showing in Figure 4.

Figure 4. Structure of the fuselage made to be tested

3.4 Financial Logistics

The experience gained in the aerodesign during the years of competition, from the point of view of project management in the economic area, allows to have in a practical way how the economic factor affects the development of the project. In all engineering projects the economic factor is decisive in the main decision-making, such as: Materials to be used in the prototype, manufacturing techniques, number of aircraft to be taken to the competition are just some of the questions constantly answered by this area.

Due to the high cost of the project the team searches through sponsorship, printing service, monthly fee paid by the members to meet the costs estimated by the project. The big challenge is to stipulate the total cost and in what time the funding is to be obtained so that the raw material is delivered by the suppliers and properly processed by the team members to generate the desired aircraft. The construction errors are a determining factor for the final weight of the project and constantly taken into account because as it is a competition the team always seeks to use new techniques and use specific materials for the best performance of the aircraft.

4 Learning in Competition Team

From the perspective of development of an aeronautical project, the SAE Aero Design competition stimulates the construction of a professional profile according to the market demands by proposing an organizational structure for teams, as seen in industry. With this in mind, the Mamutes do Cerrado team developed skilled research segments for the development of their projects, evidencing that the learning encouraged by the competition has its greatest relevance even before its accomplishement.

A knowledge assessment survey executed with team participants reveals that for 40% and 45% of the people consulted, respectively, the quantity and quality of knowledge acquired is considered very good (Figure 5). This satisfaction survey confirms the competition importance for the training of future engineers.

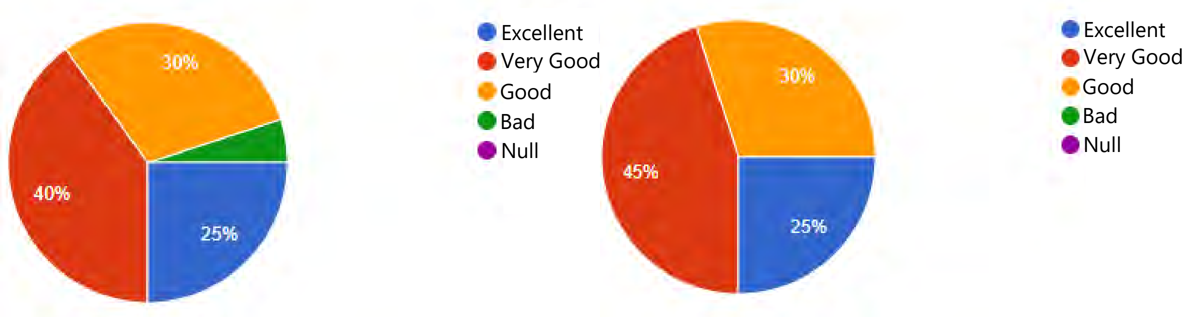

Figure 5. Survey about the quantity (left) and quality (right) of acquired knowledge.

Faced up to the real challenges of the aeronautics industry, due to the AeroDesign competition, the team has been searching for solutions to the problems of multidisciplinary optimization of conflicting design requirements, weight reduction through structural optimization, instrumentation and flight tests of the developed prototypes, as well as the development of new manufacturing methods and use of innovative materials. Such decision-making shows that the learning about procedures of the engineering projects, to 70% of the members, is considered to be adequately satisfactory (Figure 6).

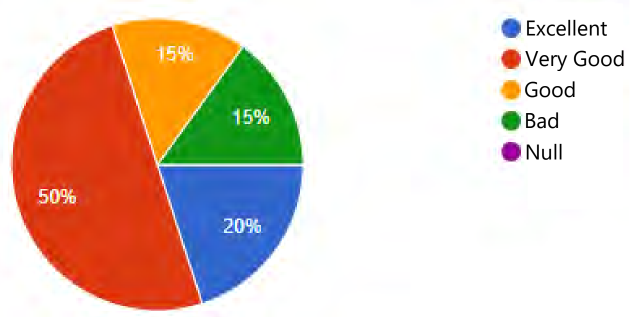

Figure 6. Survey about the design engineering knowledge.

5 Conclusion

In the final analysis, it is possible to notice that the participation on an aerodesign team can really improve the way people will handle real engineering problems. That occurs because there people can practice teamwork, that is almost never seen in a classroom, except in a few disciplines that requires final projects. But in the aerodesign is different since is a much larger group of students, and a multidisciplinary project. So you need to learn how to manage that group.

The team work turns the whole learning process funnier, this way, even when solving problems is hard, it can be achieved in a fun way, gathering ideas of each student.

Not to mention that considering it is a real project, it is necessary to use almost all of the existents variables that influence on the flight or the airplane might not even leave the ground. There can't be any simplifications as in a class or test. By the end of the project, solving problems, managing large groups of people, assembling a project and applying theoretical knowledge in a real life situation skills will definitely be improved.

In case of having a future problem alike this, the person who has worked weeks to solve something similar, might overcome the challenge in an easier way than a person who has studied weeks to a test that has a similar question

After the exposition of data, it gets clear that the experience that was gained by the team members will really help in the student's career. It happens because the student is not only solving an exercise, but he/she is working hard with his/her classmates to solve a realm problem. Facts like that are stored in memory easier than subjects that were studied for a test.

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The experience of Peer Instruction in a Soil Mechanics class at the Universidade Estadual de Santa Cruz, Brazil

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Abstract

This paper aims to present the results of applying a variation of Peer Instruction - PI in a Soil Mechanics undergraduate course at the Universidade Estadual de Santa Cruz - UESC, in Ilhéus, Brazil. The idea of applying PI in this course came as a response to the high dropout and retention rates perceived by the teacher in previous soil mechanics classes. The class of 31 students was divided into two groups, one of which met weekly to discuss the content of the following classes and another one that just relied on traditional learning methods. In the classroom, both groups answered a set of conceptual questions, applied after an initial presentation of the content of the scheduled class, and the teacher acted based on the students' answers as recommended by PI. The results show that the students who studied previously exhibited a better conceptual understanding of the topics of the course and, even in quantitative exams, obtained better grades than those students who just relied on traditional learning methods. Besides, it was found that the students in PI had lower absence and dropout rates. These results show that PI can be effective in Soil Mechanics classes both by increasing student involvement in class and by improving students' conceptual understanding related to the content of the course, what can be seen in lower dropout rates and higher grades.

Keywords: Peer Instruction; Soil Mechanics; Traditional Learning Methods; Conceptual Understanding.

1 Introduction

The technological revolution changed the professional profile sought by the companies, therefore bringing the need for a different approach to higher education. As Goldberg (2010) states, after the Industrial Revolution engineering education was structured to be following the requirements of mass production and specialized workforce. From the technological revolution, that super specialization in engineering showed to be insufficient to the new demands of the market. As now the companies seek professionals more devoted to innovation and entrepreneurship, education in engineering is currently intended to develop the student's critical thinking, self-sufficiency, leadership and workgroup (Monteiro et al., 2012).

Due to the technological revolution, the sources, the amount and the velocity of information increased, what transformed the aspirations and interests of the students. In the current conjuncture, social media, the internet, and television have seemed to be more attractive to the student than the in-class traditional environment that, on many occasions, is predictable, static and without challenges (Cardoso & Lima, 2012).

Although all the transformations brought by these new technologies, it has been noticed that even senior year students have difficulties on asking questions, labeling technologies, decomposing design problems, generating and communicating ideas. That shows that traditional learning methods may be forming engineers that neither integrate the acquired information nor can execute deeper analysis about them (Goldberg, 2010).

In this sense, Bulgraen (2010) presents that the educator needs to renew the way he teaches to serve his students in the best possible way and learn how to teach. The way the teacher intervene, and his role in the educational practice, then will be through orientation and mediation to provoke and instigate the students to think critically and assume the responsibility of their learning process. It is not easy, though, to change that scenario, mainly because it seems to exist certain systemic rigidity on the part of some educators and institutions.

To address that question, a set of active learning methods have been proposed, and a group of researchers has proved them to be effective (Araújo & Mazur, 2013; Estevão, Gott, & Oliveira, 2015; Lasry & Mazur, 2008;

Crouch & Mazur, 2001). These approaches tend to define specific roles for students and teachers, putting the student as an active agent and the teacher as a figure that orients and guide the students in that process (Estevão et al., 2015; Bulgraen, 2010; Santos, 2010).

Thus, this paper aims to present the results of applying the active learning method Peer Instruction - PI in a Soil Mechanics I undergraduate class at the Universidade Estadual de Santa Cruz – UESC, in Ilhéus, Brazil, and compare the performance of the students who were using PI with the performance of the students using traditional learning methods.

2 Literature review

The following sections present a panorama for higher education and give an idea of the impacts of applying active learning methods in engineering.

2.1 Panorama of education: active vs. traditional learning methods

Education in pre-college and during college and undergraduate levels have posed greater challenges to educators and institutions. The interests and abilities of the students nowadays are different from those of previous generations. Students nowadays process more information in less time and are more able to get along with mental challenges. Besides, traditional learning methods, for many times, are neither able to provide a significant and contextualized learning nor develop abilities and competencies for professional and personal life. Therefore, it is harder for the teacher to attract and keep the attention of students (Moura, 2014). Cardoso & Lima (2012) state that traditional teaching and learning environments are usually predictable, static, without challenges and tedious, particularly when compared to the internet, television and social media.

Another issue that challenges educators and institutions is the lack of motivation perceived in many students and its impacts on their performances and the school dropout rates. The learning process needs to be significant to the student, that is, it should be related to the student's knowledge and experiences, permitting him to formulate problems and questions of interest and apply what he learned to life situations (Santos, 2010).

Moura (2014) still presents that it is difficult to apply active learning methodologies in educational environments due to a systemic rigidity, or a fear of undermining traditional approaches. That fear may also be related to a deficient formation by the part of the teacher, who may not have been exposed to active learning methodologies throughout his formation. On the part of the teacher, the active learning methods presuppose "a solid theoretical, psychological and pedagogical formation to know the nature of the pedagogical act" (Rosso & Taglieber, 1992).

In a scenario where usually the teacher is a specialist in his field of knowledge, but not necessarily masters educational and pedagogical areas (Santos, 2010), a broader comprehension of fundamentals and potential of the applied method for improving the learning/teaching process is essential. It is important to mention that the active learning methods are neither centered on the technique by itself nor in the teaching resources, but rather in the posture and qualification of the teacher (Rosso & Taglieber, 1992). Estevão et al. (2015) state that the teacher has to make a bigger effort and recognize that nowadays students learn autonomously, reflecting upon which role he intends to play.

As Bulgraen (2010) presents, besides being an educator and a transmitter of knowledge, the teacher is a mediator between the student and the knowledge. By this way, it is possible that the student learns how to think and question by himself, changing his attitude from a passive receiver of information to an active agent of his learning process (Barbosa & Moura, 2014; Estevão et al., 2015). In this sense, the teacher is not transferring knowledge but permitting that the students build their knowledge in a critic and active manner. On the part of the student, the difficulty is that active learning approaches require them to change their mentality from a dependence on the professor to self-sufficiency (Cardoso & Lima, 2012).

Usually, traditional approaches to teaching tend to reduce education to a transfer of information (Mazur, 2009), which may only reinforce the dependence of the student on the teacher. For more complex it may be, information is something to be given whereas knowledge is something to be built through the interaction between the person with the context in which he wants to learn and his previous knowledge. Traditional educational approaches privilege the transfer of information whereas active learning methods aim to turn information into knowledge (Moura, 2014). Table 1 presents a comparison between active and traditional learning methods based on what was discussed.

Table 29. Comparison between traditional and active learning methods.

Methodology	Traditional	Active
Education is seem as	Transfer of information (mostly)	A process where information is used to produce knowledge
Class environment	Usually static, predictable	Dynamic
Role of student	Passive agent	Active agent
Student attitude	Tends to depend on the teacher	Self-sufficiency
Role of the teacher	Knowledge holder and transmitter	Advisor, guide, mediator
Pre-requisites to be a teacher	Master his field of knowledge, not necessarily education and pedagogy	Master his field of knowledge, besides education and pedagogy
Teacher's formation	Only technical formation is required; the teacher may have not been exposed to active teaching and learning methods	Presupposes a solid theoretical, psychological and pedagogical formation
Information is	Given; passive to be memorized	Used with the previous experiences of the students to build knowledge

2.2 Peer Instruction

Peer Instruction - PI is an active Learning Method, developed at the beginning of 1990 by Professor Eric Mazur at the Harvard University. The method has as guiding principle the previous study of the contents by the students, with the objective of improving the argumentation and discussion in the classroom through the students' conceptual understanding. Worldwide, the method has been widely used, although many teachers in Brazil do not know it (Araújo & Mazur, 2013).

The PI method "is a student-centered approach that has demonstrated effectiveness in university settings" (Lasry et al., 2008). In this method, the student is the one who acts while the teacher is the one who orients and facilitates (Estevão et al., 2015; Cardoso & Lima, 2012).

In PI the students should study the subjects of the class before the teacher explanation and answer some conceptual questions related to the content during class. The teacher orients the theme and its primary literature, and the students have to search and study them. It can be said that the idea behind the method is to teach through questioning rather than by exposing. Thus, PI creates an interactive environment that helps students to learn.

In class, the teacher briefly explains the content of the class and apply a set of conceptual questions related to what he just presented. These questions do not involve any calculations, focusing only on the concepts that are assumed as essential for the assimilation of the content. The students are given some time to formulate their questions, and after that, they have to discuss their answers with their peers (Mazur, 2015; Crouch & Mazur, 2001).

In summary, the conceptual tests are applied as follows (Mazur, 2015):

- one minute is given to the question proposition;
- the students are given one more minute to formulate their answers;
- in one to two minutes the students discuss their answers in groups of two to four students;
- the students have the chance to change their answers based on the discussion they just had;
- the teacher gets feedback and finally explains the question.

Based on the first answer of the students for each conceptual question, the teacher may act differently. If for any question less than 30% of the answers are right, the teacher should explain the content again and apply new related questions. If from 30% to 70% of the answers are right, the teacher should propose discussions in groups of two to four students and reapply the question to verify whether the students could learn from their peers. Finally, if more than 70% of the answers are right, the teacher can proceed to the next topic of the content (Lasry et al., 2008).

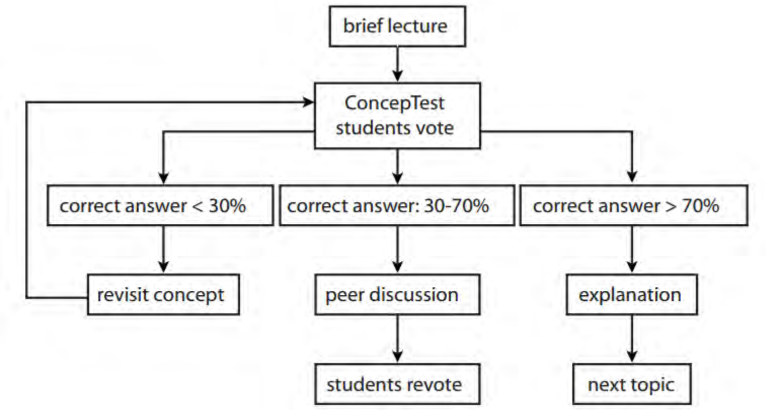

Figure 1. The peer instruction implementation process. Source: Lasry et al. (2008).

Even though PI focuses on improving the conceptual understanding of the students about the course, the problem-solving skills of the students grow as well (Crouch & Mazur, 2001; Lasry et al., 2008). In PI classes, more time is devoted to conceptual understanding and less time is dedicated to traditional problem-solving skills, what could make one think that the performance of the students exposed to the method in problem-solving would be impaired. Lasry et al. (2008), however, presents that "providing a solid background allows students to be more effective in problem-solving" as the grades of the students exposed to the active method on their finals exams were higher than the final exam grades of the students taught by traditional methods.

Finally, PI is also helping on reducing failure rates since the dropout rates decrease in classes that apply PI. Lasry et al. (2008) found that the number of students who dropout classes that use PI are 2-3 times lower than the number of students who dropout the same classes when they use traditional learning methods.

3 Methods

An exploratory research was performed using a quantitative research methodology on the possible impacts of using PI in an undergraduate level Soil Mechanics I class of students majoring in Civil Engineering at UESC in the first semester of 2017. The methodological option chosen was the comparative one since the average grade of the students using PI was compared to the average grade of the students using traditional approaches.

For an undergraduate Soil Mechanics I class of 31 students a variation of PI was applied since a control group was created with the intent of verifying the fulfillment of the assumption of the method of the previous study of the contents by the students. Ten places were placed in that control group and participation was voluntary. As the demand was higher than the number of places, a drawing was made to guarantee the randomness of the results and the ten students were drawn. The other 21 students, on the other hand, continued using traditional learning methods.

Based on the teacher proposal, the control group should meet weekly and discuss the content of the classes. This group had a teaching assistant with the function of creating a propitious environment for discussion, and that would intervene only when someone gave inconsistent information or when no one could understand something assumed as fundamental for the discussion.

Following this group discussion, the students met in class and, after the teacher's explanation about the class' content, answered a set of conceptual questions. These questions were related to the material just presented by the teacher and should be answered by all the students in the class. On average five to six conceptual questions were applied per 150-min class. These conceptual questions did not involve any calculations and were based solely on what the teacher had just presented.

As in Brazil it is not usual to use clickers in class, Google Forms was used as a tool for answering the questions. When these questions were applied, the students just needed to open a linked form that had been shared at the beginning of each class and choose the alternative they thought was correct.

As soon as a student answered the form, the teacher could see the answers, a summary of the percentages of answers for each option and took action based on the answers as the PI method recommends (Figure 1).

At the end of the semester, the results for the conceptual questions, quantitative exams, lab sections, the number of absences and the dropout rates were put into a spreadsheet and analyzed. The Figure 2 presents a scheme of the method applied for this class.

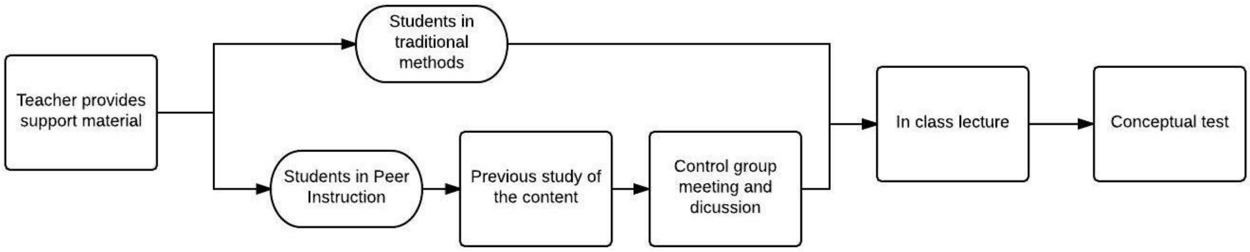

Figure 2. Scheme of the PI application in Soil Mechanics I.

4 Results

The results and discussions presented in the subsequent sections were obtained in a class of 31 students attending an undergraduate Soil Mechanics I course at the Universidade Estadual de Santa Cruz, in Ilhéus, Brazil, in the first semester of 2017.

4.1 Conceptual tests

Over the semester, eight conceptual tests were applied. As mentioned, each conceptual test consisted of 5 to 6 questions related to the content being presented in class. The results shown in Figure 3 present the percentage of right answers for each test considering both groups of students.

As we can see in the Figure 3, except for test I, the members of the control group answered more right questions than those just relying on traditional learning methods. These results were expected since the members of the control group were studying the subjects of the class previously and were expected to have a better conceptual basis than those who were just exposed to the content in class.

Calculating the average value for the percentage of right answers throughout the semester for each group, it can be seen that the performance of the members of the control group was 4% higher in the conceptual tests than the performance of the students not using PI (74% vs. 70%).

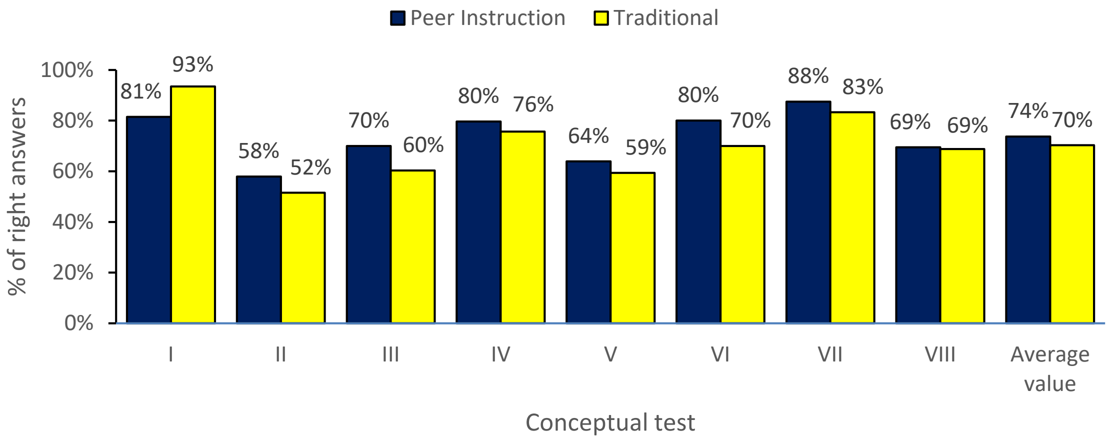

Figure 3. Results from conceptual tests.

4.2 Evaluation

The Figure 4 presents the average grades for both groups of students throughout the semester. It shows that students using PI graded 6.2 out of 10.0 while students relying on traditional methods graded 4.9 out of 10 over the semester, what represents grades 13% higher for the students in the control group.

The results in the Figure 4 are the average grades considering 4 credits (3 problem-solving exams and 1 grade for lab sessions). As it can be seen, even though in PI more time in class is devoted to conceptual understanding, the problem-solving skills of the students improve as well.

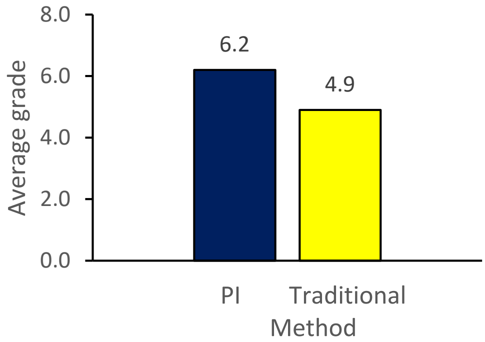

Figure 4. Average exams grades of the students who completed the course.

Moreover, we analyzed the results of the students who took the final exam and the results of the students who were approved in the course without taking this exam. At the Universidade Estadual de Santa Cruz, the students are expected to get an average grade of at least 7.0 points out of 10.0 in the regular credits in the semester to get approved. In the case of the student get an average grade ranging from 1.7 to 6.9, he has the chance to take a final exam and, after a composition of the average grade in the semester and the grade in the final exam, grade at least 5.0 points to get approved. The results are shown in Figures 5 and 6.

The Figure 5 presents the average grades for the students approved without final exam. Again, the results for the students using PI were higher than the results for the students using traditional methods, in this case, 2% higher.

Now, considering the students who took the final exam, Figure 6 shows that the students in PI graded 12% higher than the students using traditional methods. Comparing these results with those obtained for the students who were approved without taking the final exam, we can observe that PI improved the performance of the students that seemed to have more difficulty with the course and less impact on the performance of the students who seemed to understand more of the contents throughout the semester.

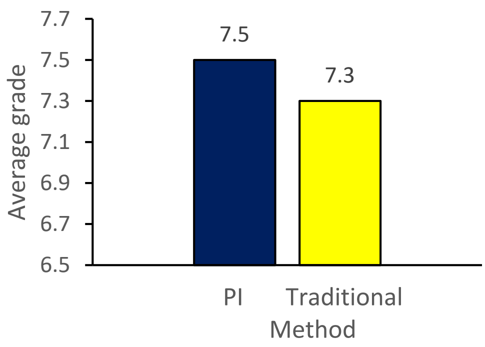

Figure 5. Average grades of the students approved without final exam.

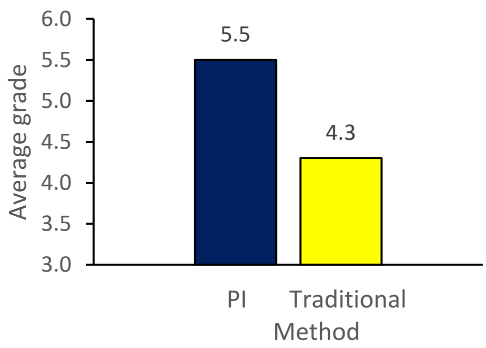

Figure 6. Average exams grades of the students who needed the final exam at the end of the semester

4.3 Missed classes, dropout and retention rates

The Figure 7 shows the average number of missed classes for the students under PI and Traditional learning methods. As it can be seen, the average number of missed classes for the students under PI was half of the average value observed for the students in traditional learning methods. These results show that PI may encourage the students to attend classes as now they actively participate in the discussions.

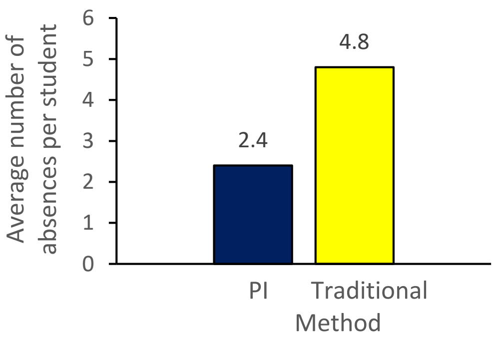

Figure 7. Average number of absences in the semester per student

The Figure 8 presents the dropout rates for both groups of students in the class. Here, dropout rates are considered not only for the students who withdrew from the course but also for the ones who gave up on the final exam, although being eligible for taking it. The results show that the dropout rate for students using PI in this course was almost half of the rate observed for students using traditional learning methods (10% vs. 19%), a value that is similar to the ones found by Lasry et al. (2008).

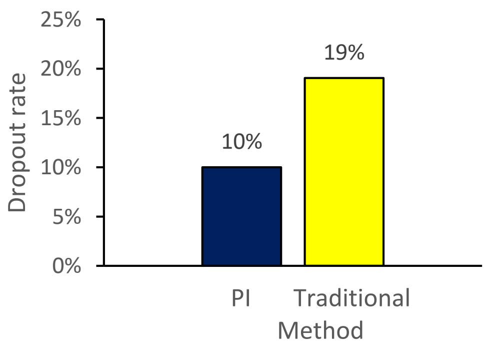

Figure 8. Dropout rates over the semester

Finally, the retention rate was also measured and is shown in Figure 9. As it can be seen, the retention rate for the group of students using traditional teaching methods is more than the double of the retention rate observed for students using PI, 67% vs. 30%, what shows that PI may help on reducing retention rates.

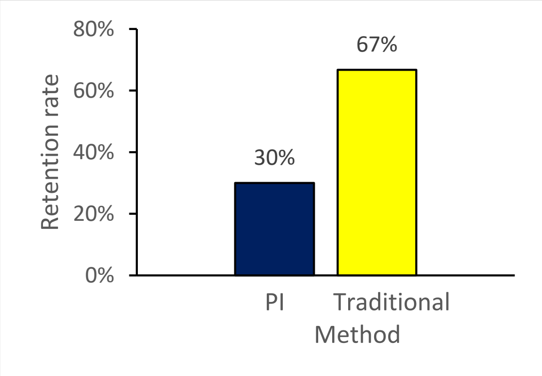

Figure 9. Retention rate

5 Final Considerations

The application of PI in Soil Mechanics I at UESC indicated that the method might be suitable for engineering courses mainly because the method improved students attendance in the classroom and because their grades increased when comparing their results with the results of students using traditional learning methods in the same course.

Throughout the semester, the teacher observed certain increases in the discussions in the classroom, mainly when the students were asked to convince their peers about their answers. It was found out that, in many occasions, the students who had given a wrong answer realized they had made a mistake while trying to convince their peers or when they heard the answers of their peers. Besides, because part of the students in the class had some understanding of the content, the interactions with the teacher improved as well as the students based their questions and opinions on the previous knowledge they have gained while studying by themselves, what could also be noticed in the discussions of the control group.

Finally, considering the promising results found in the initial applications of PI in Soil Mechanics, the authors are currently working with different active learning approaches to determine their potentialities when applied in engineering education and to produce a bigger database to help other teachers that may want to use them.

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First steps in Engineering: Promoting Engineering disciplines in middle education students from public schools in Bogotá

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Abstract

By 2018, the deficit of engineers in Colombia will be 93,000 in areas associated with agriculture, electricity and technology. This statistic contrasts with the lack of interest and rejection of middle school students (ninth, tenth and eleventh grades) to study Engineering. For this reason, it is required to intervene students' education and professional orientation during these key ages, promoting Engineering as a higher education option for them. To achieve this goal, the District Education Secretariat (SED) in collaboration with the Colombian Association of Engineering Faculties (ACOFI) had created the Engineering Challenge for Student Wellness (IBE), which has been implemented since July of 2017. Ten public schools in Bogotá are annually selected, where middle school students individually develop an innovative proposal in one of the three themes related to Integral Plans of Student Wellness (PIBES): school meals, school mobility and risk management. Undergraduate students from schools of Engineering support and orient these proposals. All the participating schools of Engineering have earned a high-quality accreditation, awarded by the Ministry of National Education (MEN). The undergraduate students help middle school students to transform their proposal into an engineering project that will be implemented, and will be presented at International Encounter of Engineering Education (EIEI) organized by ACOFI in Cartagena. This study, aligned with the IBE Challenge framework, aims to analyze middle school students' perceptions towards Engineering, evaluating their self-efficacy when formulating engineering projects, and their motivation towards studying an engineering career.

Keywords: Engineering Education; Middle School; Student Wellness.

1 Introduction

The Engineering Challenge for Student Wellness (IBE) is an alliance project of the District Education Secretariat (SED) and the Colombian Association of Engineering Faculties (ACOFI) developed in the District Education Institutions (IED) linked to the Integral Plans of Student Wellness (PIBES).

1.1 IBE Challenge

SED and ACOFI promote a challenge for students of IEDs that are chosen annually in different locations in Bogotá. For the challenge the students propose an individual idea that solves a problem that affects the student wellness of IED, related to one of the three thematic axes of the PIBES, that involve processes of healthy lifestyles, sustainable school mobility and risk management.

The best ideas proposed will be transformed into engineering projects by a volunteer that is an engineering student, who will accompany the process of ideas review and projects formulation. These projects will be evaluated by professors from the Faculties of Engineering associated with ACOFI and by delegates from the Wellness Direction of SED. Finally, the three projects with the highest score given by the juries, will be sponsored with all expenses paid to participate in the International Encounter of Engineering Education (EIEI) organized annually by ACOFI at the end of September in Cartagena. In the EIEI, the three best projects are presented, and their authors receive the "Eduardo Silva Sánchez to the future engineer" distinction. And the rest of the participating projects are presented at the University Fair, organized each november by the SED and the engineering faculties (Secretaría de Educación Distrital y Asociación Colombiana de Facultades de Ingeniería, 2017).

The development of the IBE Challenge involves different actors that participate in its phases, such as middle school students, volunteer engineers, territorial managers and juries. The middle school students participate actively in their professional orientation process, to promote their interest and improve their perception of engineering as an option for their higher education. The volunteer engineers will share their academic experience during the undergraduate, to be a source of inspiration for middle school students, and to promote the interest and knowledge by engineering. For their commitment, these engineering students will be certified by the SED and ACOFI as volunteers of the Challenge. The territorial managers are professionals of the Wellness Direction of SED, which will facilitate the entrance to the IED and the interaction with the middle school students.

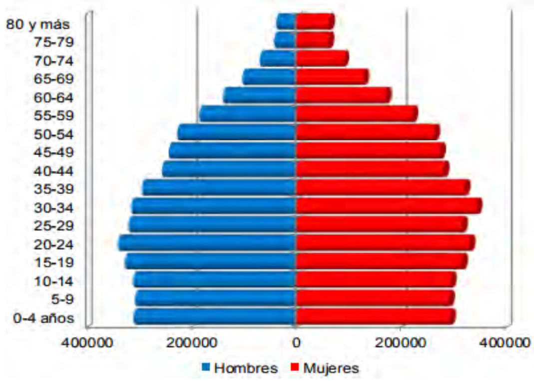
The EIEI is the "stage in which deans, academic and administrative managers, professors and students of engineering, in interaction with representatives of the productive sector, state entities, unions and citizens to study, analyze and reflect on the problems and expectations of society and propose strategies that allow human development to be compatible with productivity and sustainability, in such a way that faculties, schools and engineering programs propose viable, innovative, sustainable and competitive solutions that ensure a positive impact on society" (Asociación Colombiana de Facultades de Ingeniería, 2017). Under the EIEI is developed the Colombian Forum of Engineering Students (FCEI) organized by the ACOFI Student Chapter, which has been proposed to visualize projects in technology, innovation and social development from the best engineering schools (Sanchez, 2017).

The Universities Fair is the first fair between engineering faculties and IED students of Bogotá, to make visible the student wellness projects of the middle school students supported by the volunteer engineers, and to allow their interaction with the engineering programs and the faculties that offer them (Secretaría de Educación Distrital y Asociación Colombiana de Facultades de Ingeniería, 2017).

1.2 Middle education in public schools of Bogotá

To understand the context of this study, we will show some statistics of the public schools of Bogotá, to know the official statistics of the population of school age that is in the middle school, that is, the students of ninth, tenth and eleventh of the IED. From this population, a sample of the students of the seven IED selected in the IBE Challenge is obtained.

Bogota reached 7,878,783 habitants in 2015, which represents 16.31% of the total population of Colombia. For that date, the population group of 5 to 14 years decreased 0.94% but the group of 15 years and older increased 1.98% (see Figure 1.a). Additionally, the decreasing population of school age, that is, children and adolescents between 3 and 16 years of age, shows a decrease of 0.5% in the population group of 6 years and older (see Figure 1.b) (Secretaría de Educación Distrital, 2015),



Rangos de Edad	2011	2012	2013	2014	2015
3-4 años	237.284	238.208	239.235	239.848	240.192
5 años	118.464	118.833	119.228	119.626	119.926
6-10 años	599.711	597.402	596.402	596.777	597.915
11-14 años	501.741	497.716	493.643	489.374	485.409
15-16 años	259.418	257.768	255.921	253.987	252.059
TOTAL	1.716.618	1.709.927	1.704.429	1.699.612	1.695.501
Variación anual	-0,47%	-0,39%	-0,32%	-0,28%	-0,24%

Figure 1. (a) Population pyramid of 2015 and (b) population of school age by age of rank in Bogotá (Secretaría de Educación Distrital, 2015).

This population of school age should be guaranteed access to education, access that is measured by the official enrollment, which is made up of students from district schools, schools in concession and private schools that have a contract with the District Education Secretariat (SED).

Nivel	2011	2012	2013	2014	2015	% Participación
Preescolar	63.638	61.004	60.063	78.915	87.024	10%
Primaria	399.262	377.838	356.549	347.474	342.741	39%
Secundaria	372.087	356.370	335.996	330.256	317.368	36%
Media	148.426	140.745	130.569	130.412	130.403	15%
Total	**983.413**	**935.957**	**883.177**	**887.057**	**877.536**	**100%**

Estrato	2011	2012	2013	2014	2015
0	79.378	71.029	60.961	68.627	85.812
1	178.779	170.227	160.297	157.269	154.562
2	503.691	485.290	468.246	468.644	455.649
3	213.057	201.687	187.191	186.152	175.496
4	6.737	6.156	5.157	5.047	4.763
5	1.092	989	849	815	754
6	679	579	476	503	500
Total	**983.413**	**935.957**	**883.177**	**887.057**	**877.536**

Figure 2. Evolution of the official enrollment between 2011 and 2015 according to (a) educational level and (b) social stratum.

The official enrollment by educational level from 2011 to 2015 presents an increase in the preschool level and a decrease in the other levels. Additionally, the target population of this research is middle education, a level that represents 15% of participation (see Figure 2.a), and most of the official enrollment is in social strata 1, 2 and 3 (see Figure 2.b). (Secretaría de Educación Distrital, 2015).

1.3 Higher education in Bogotá

In addition to the statistics of middle education in Bogota, it is important to know the statistics of access, quality and progress of higher education, especially of undergraduate in Engineering, to recognize the importance of the promotion of Engineering as an option of higher education. The National Information System of Higher Education (SNIES) annually reports indicators of access, quality and progress of higher education in Colombia. The latest reports of the SNIES date from 2011 to 2015, and comparing each region of the country with the national average it can be highlighted that Bogotá presents the best indicators of access, quality and progress (see Figure 3). It can be evidenced as in the national average, the access has increased significantly, while the quality remains and does not increase proportionally to the access, and the progress has been decreasing slightly in the same period.

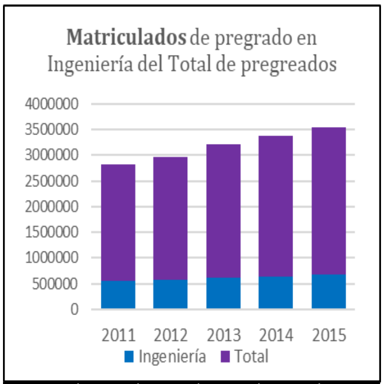
Acceso	2011	2012	2013	2014	2015
Colombia	29,10%	29,90%	32,40%	40,10%	42,20%
Bogotá	57,30%	58,10%	60,90%	75%	76,20%

Calidad	2011	2012	2013	2014	2015
Colombia	27,90%	27,90%	28,80%	28,10%	28,00%
Bogotá	40,10%	40,70%	37,50%	37,80%	38,30%

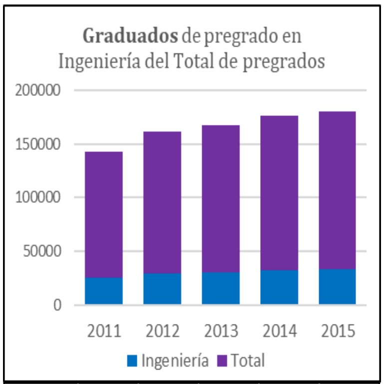
Progreso	2011	2012	2013	2014	2015
Colombia	27,10%	26,40%	27,40%	24,90%	24,60%
Bogotá	40,10%	40,70%	37,50%	37,80%	38,30%

Figure 3. Statistics of (a) access, (b) quality and (c) superior progress from 2011 to 2015. Edited from (Indice de progreso de la educación superior, 2015).

The increase in access can also be evidenced because the number of enrolled students in all undergraduate programs increased from 2,285,451 in 2011 to 2,857,686 in 2015 (see Figure 4.a). Of the total of undergraduate programs, it is possible to distinguish the percentage of enrolled students in Engineering, which increased from 23.92% in 2011 to 24.06% in 2015 (Estadísticas de matriculados, 2015).



Matricula	2011	2012	2013	2014	2015
Ingeniería	546612	572735	623124	647935	687661
Total	2285451	2399702	2583743	2723424	2857686



Grado	2011	2012	2013	2014	2015
Ingeniería	25158	29087	30935	32955	33342
Total	117971	132125	136582	142924	146997

Figure 4. (a) Enrolled and (b) graduates in Engineering of the total number of undergraduates. Edited from (Estadísticas de matriculados, 2015) (Estadísticas de graduados, 2015).

Simultaneously, the increase of enrolled students has an increase in the number of graduates, from 117,971 in 2011 to 146,997 in 2015 (see Figure 4.b), of which the percentage of engineering graduates has increased from 21, 33% in 2011 to 22.68% in 2015 (Estadísticas de graduados, 2015).

2 Methodology

The IBE Challenge is composed of four phases: the announcement phase, the ideas review phase, the projects formulation phase and the evaluation phase.

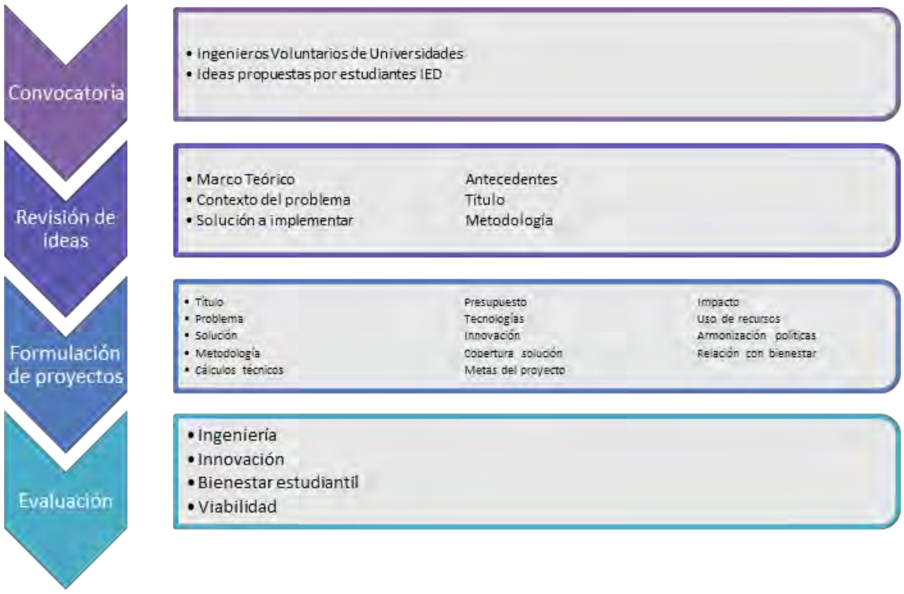


Figure 5. Phases of IBE challenge. Edited from (Secretaría de Educación Distrital y Asociación Colombiana de Facultades de Ingeniería, 2017)

Through the phases of the IBE Challenge, the student individually develops the OCDIO methodology, that is, Observation, Conception, Design and Implementation, without the operation phase that is carried out with the support of the SED, the IED and the experts in each theme to be implemented. The OCDIO methodology allows to evaluate the self-efficacy of the student in the development of his engineering project, which turns out to be the product that the student performs at the end of the challenge. This methodology will be developed iteratively since the student enrolls his idea through the registration form, continues his idea with the idea review form and transforms his idea into a project with the project formulation form. From these forms, the student begins to get involved in the daily work of engineering, in which a problem and its context is identified (observation), the possible solutions are proposed (conception), a solution is designed focused on improving the student welfare (design) and an action plan is proposed for the implementation of solution (implementation).

2.1 Announcement phase

This first phase involves the announcement of engineering students (volunteer engineers) in the universities and the nomination of ideas proposed by students of the District Education Institutions (IED) chosen annually to participate in the challenge.

Volunteering certified by the SED and ACOFI, is aimed to enrolled students in any Engineering, who are studying at least fifth semester, which implies having approved the common core of Engineering, which according to the Ministry of National Education is approved in the first half of undergraduate. Additionally, the volunteer engineer develops a focus on engineering education and social responsibility during the challenge. For the convocation of volunteer engineers, through the Student Chapter of ACOFI, some engineering faculties of Universities of Bogotá accredited by the Ministry of National Education were visited. The students interested in being volunteer engineers must be endorsed by the directives of their Engineering faculty, so that ACOFI and SED can be formalized their commitment and connection with the challenge.

The Wellness Direction is part of the Undersecretary of Access and Permanence of the District Education Secretariat. This Direction, promotes the student wellness in the District Educational Institutions (IED), and for this purpose created the Integral Plans of Student Wellness (PIBES). The objective of the PIBES is to strengthen and harmonize the institutional programs of student wellness, to promote the permanence of students in the IED.

The PIBES do not intervene in the provision of student welfare services, however, they develop pedagogical actions focused on three themes or pedagogical lines such as risk management, sustainable school mobility and healthy lifestyles. Risk management develops skills and competencies to prevent risks and respond to emergencies in the school environment. Sustainable school mobility develops citizen values, as well as self-care practices in mobility processes in any means of transport from home to school, and vice versa. Healthy lifestyles seeks that students maintain an adequate balance in nutritional consumption habits, through physical activity (Secretaría de Educación Distrital y Asociación Colombiana de Facultades de Ingeniería, 2017).

The postulation of ideas in the IED is carried out in each of the ninth, tenth and eleventh grades of La Joya school, Manuel Elkin Patarroyo school, Menorah school, Quiba Alta rural school, Rodrigo de Triana school, Simón school Rodríguez and school Nicolás Gómez Dávila. The territorial manager presents the PIBES to the middle school students and the volunteer engineer presents the guidelines to develop the individual idea and the benefits of participating in the challenge.

Each student will develop an individual idea to improve the student wellness of their IED in healthy lifestyle, sustainable school mobility or risk management. To register their idea, the student must fill out clearly, briefly and concisely the registration form with the title, the PIBES themes, the description, the target population, the methodology and engineering that is related to the proposed idea. This form is delivered by the student to the IED directives, that chooses the best 5 ideas according to the criteria they establish relevant for their selection and sent to the coordinating team via email.

2.2 Ideas review phase

This phase involves the support of the volunteer engineer for the consolidation of the idea proposed by the student. The student and the volunteer engineer must complete the idea review form, which includes an improved version of title, the theoretical framework, the context of the problem, the solution to be implemented, the existing solutions, the methodology and the corrections from volunteer engineer feedback. The completion of this format requires presential and virtual visits of volunteer engineer to the IED, to guide and support the student as many times as necessary. This phase of consolidation of the idea, is the first iteration that the student performs following the OCDIO methodology, for which numerous corrections can be presented in this first development of the idea that will be improved with the support of the volunteer engineer.

2.3 Projects formulation phase

The idea proposed by the student and reviewed by the volunteer engineer, is now transformed into an engineering project whose implementation and viability will be analyzed in detail. The project formulation form includes the project title, the definition of the problem, the solution description, the methodology, the technical calculations, the budget, the use of resources and technologies and the innovative characteristics of the solution, the coverage, the goals and the project impact, the relationship of the project with student wellness and its harmonization with school and SED policies.

2.4 Evaluation phase

The projects are evaluated by a jury of professors and executives of the engineering faculties chosen by ACOFI and by pedagogues of Wellness Direction of SED. This jury will evaluate the self-efficacy of the student to develop an engineering project, through four evaluation criteria: engineering, innovation, student wellness and feasibility of the implementation. These criteria and their sub-criteria are qualified by the jury for each project, assigning the corresponding points according to the qualification matrix (see Table 1 to 4).

The Engineering criterion involves defining a problem, presenting a solution in a schematic way, describing a methodology with mathematical calculations and defining the resources and budget that allows reaching to solution implementation.

Criterios		Puntuación
INGENIERÍA	Definición del problema (10 puntos):	8-10: Presenta claramente el problema y describe sus causas y efectos.
		6-7: Se entiende que hay un problema sin un contexto definido.
		0-5: No es claro el problema y no se ajusta al contexto.
	Diagrama de la solución (10 puntos).	8-10: Clara representación gráfica de la solución
		6-7: Se presenta la solución sin incluir sus componentes
		0-5: No es claro el diseño, parece una construcción improvisada
	Descripción metodológica de la implementación (10 puntos):	8-10: Presenta metodología clara y coherente con tiempos implementación
		6-7: Menciona la metodología sin un orden lógico y usa tiempos improvisados.
		0-5: No es clara la metodología y sus tiempos de implementación.
	Cálculos técnicos de la solución (10 puntos):	8-10: Presenta datos y cifras justificadas en cálculos y estimaciones.
		6-7: Menciona algunos cálculos que no son necesarios para la solución.
		0-5: Presenta datos improvisados sin rigurosos cálculos matemáticos.
	Definición de recursos y presupuesto de la solución (10 puntos):	8-10: Presenta presupuesto claro y con la cantidad, frecuencia y financiación adecuada.
		6-7: Menciona el presupuesto con recursos innecesarios y cifras sin justificar.
		0-5: Presenta un presupuesto improvisado que no es coherente con la solución.

Table 1. Engineering criterion.

The Innovation criterion (see Table 2) evaluates that the proposed solution involves the use of technologies and contemplates an innovation component that distinguishes it from existing ones.

INNOVACIÓN	Uso de tecnologías en la solución (5 puntos):	4-5: Presenta claramente el uso de una tecnología viable y necesaria para la solución.
		3: La tecnología a utilizar no es viable ni coherente con la solución
		0-2: La solución no involucra el uso de tecnologías.
	Innovación en la solución (10 puntos).	8-10: Presenta una solución innovadora con beneficios claros a la población objetivo.
		6-7: Menciona una solución innovadora sin el uso eficientes de los recursos propuestos.
		0-5: La solución carece de innovación y no se ajusta al contexto del problema.

Table 2. Innovation criterion.

The student wellness criterion (see Table 3) is transversal to the PIBES themes, for this reason it is necessary to evaluate the impact of the solution in terms of coverage, the goals and the impact of its implementation.

BIENESTAR	Cobertura de la solución (5 puntos):	4-5: La solución beneficia estudiantes, población flotante y residente delcolegio.
		3: La solución únicamente beneficia a los estudiantes del colegio.
		0-2: La solución únicamente beneficia a una porción de los estudiantes del colegio.
	Metas del proyecto (5 puntos).	4-5: El proyecto es sostenible en el tiempo.
		3: El proyecto involucra una solución temporal y deficiente para contexto del problema.
		0-2: El proyecto no define claramente un horizonte de temporalidad y sostenibilidad.
	Impacto de la solución al Bienestar estudiantil (10 puntos):	8-10: Presenta claramente la relación del proyecto y su impacto al BE.
		6-7: Menciona la relación del proyecto con BE pero no justifica su impacto.
		0-5: No es clara la relación del proyecto con BE y no presenta un impacto real.

Table 3. Student wellness criterion.

The Viability criterion (see Table 4) guarantees the implementation of the proposed solution, evaluating the efficient use of resources, that the solution is in accordance with the IED policies and optimize the student wellness.

VIABILIDAD	Uso eficiente de recursos (5 puntos):	4-5: La solución hace uso eficiente de los recursos que dispone el colegio.
		3: La solución no involucra los recursos disponibles del colegio.
		0-2: Los recursos utilizados son innecesarios e injustificados.
	Armonización con las políticas de la IED y su PEI (5 puntos).	4-5: La solución contempla la normatividad vigente y las políticas del colegio y su PEI.
		3: La solución contempla las políticas del colegio pero no se ajusta a ellas.
		0-2: La solución desconoce completamente las políticas del colegio y su PEI.
	Relación con las 3 áreas de bienestar estudiantil (5 puntos):	4-5: La solución se relaciona claramente con las áreas del BE.
		3: Se entiende que hay una relación con las áreas del BE pero no se justifica.
		0-2: La solución no se relaciona con ninguna de las áreas del BE.

Table 4. Viability criterion.

The Jury makes two rounds of evaluation using the matrix of four criteria totaling 100 points (see Table 1 to 4). The Engineering criterion with 50 points, the Innovation criterion with 15 points, the Student wellness criterion with 20 points and the viability criterion with 15 points. In the first round all projects are evaluated, and the six projects with the best scores pass to the second round, and finally the three best scores are choosen.

2.5 Survey of perception

The closure of the IBE 2017 challenge was the Universities Fair, with the students of the 21 projects, the 12 volunteer engineers, the engineering faculties, the ACOFI executives and the PIBES team of the Wellness Direction. In this fair, an instrument was applied to measure, through the IBE challenge, the perception of engineering and to quantify the promotion of engineering as an option for higher education. For the design of the survey, various noise factors that did not have a significant contribution to the investigation were analyzed. In the first place, "do not know or do not respond" was not included as an answer option, because it did not provide relevant information. Age was not included as a factor, since it was not necessary to classify the population by age range, if it was already classified by grade level, to identify the experience acquired in school. Subsequently, the survey was structured in three parts, a first part in which sociodemographic indicators are asked, in the second part the indicators of engineering interest are measured and in the last part, the influence of the IBE challenge in professional orientation is evaluated.

The first part aims to characterize the surveyed population, through different factors such as school, grade level, gender and socioeconomic level. The grade level allows to identify the time of the student's stay in the school, through three levels such as the ninth grade, the tenth grade and the eleventh grade. The gender has the two traditional levels of feminine or masculine, and the socioeconomic level is associated to six strata in which a Colombian citizen can live according to the DANE. The second and third parts, evaluate two response variables such as the influence of the challenge and interest in engineering, using qualitative variables measured in ordinal scale with five ranges of assessment, from no grade (1) to very high grade (5).

3 Results

3.1 Announcement phase

After the visit made to different universities, twelve volunteers of different engineering participated during all the phases of the IBE challenge (see Table 5), who will be certified by the SED and ACOFI.

Ingeniería	Voluntarios
Ambiental	1
Biomédica	1
Civil	4
Industrial	1
Mecánica	1
Producción	1
Química	3

Table 5. Volunteers by engineering area.

There is a prevalence of students of Civil Engineering, an area of engineering closely related to the thematic issues of school mobility and risk management. There was an absence of volunteers from other engineering, such as food engineering, whose ideas and related projects were supported by chemical engineering volunteers.

3.2 Ideas review phase

The volunteer engineers were assigned according to the ideas related to their engineering, which were 38 ideas proposed by middle school students that were chosen by each of the IED.

Grado	Estudiantes
Noveno	10
Décimo	16
Undécimo	12

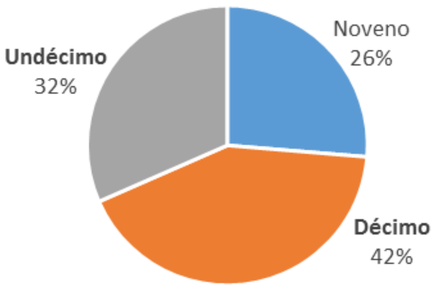


Figure 6. Number of participating students per grade level.

The selected students of best ideas of each school, are mostly tenth grade students, that is, 42% of the participating students (see Figure 6). These ideas were mostly on the theme of healthy lifestyles, representing 63% of the total ideas (see Figure 7).

Area Bienestar	Ideas
Estilo Vida Saludable	24
Movilidad escolar	7
Gestion Riesgo	7

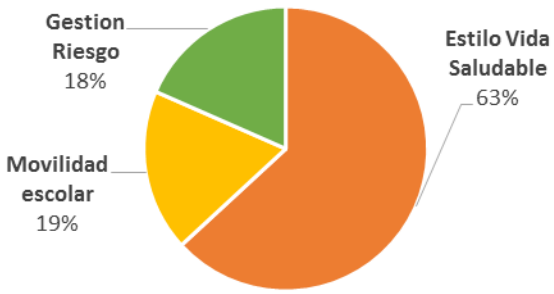


Figure 7. Number of ideas per student wellness area.

3.3 Projects formulation phase

From 21 projects, the prevalence of healthy lifestyles continues (71%) by the variety of related topics (see Figure 8). Additionally, it shows that student wellness problems are more concentrated in school feeding, physical activity and recreation.

Area Bienestar	Proyectos
Estilo Vida Saludable	15
Movilidad escolar	5
Gestion Riesgo	1

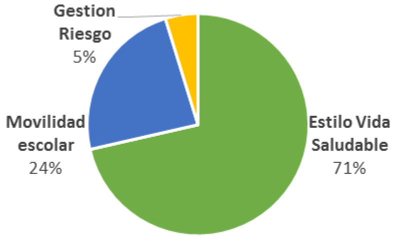


Figure 8. Number of projects per student wellness area.

3.4 Evaluation phase

The jury of four professors of Engineering faculties chosen by ACOFI and two SED pedagogues make two evaluation rounds with the same evaluation matrix (see Tables 1 to 4), and the projects with the best scores of the first round pass to the second evaluation round.

	Criterio/Proyecto	Media	Moda
INGENIERÍA	Definición del problema (10 puntos)	7,4	8,0
	Diagrama solución (10 puntos)	6,9	8,0
	Descripción metodológica de la implementación (10 puntos)	7,1	8,0
	Cálculos técnicos de la solución (10 puntos)	5,8	5,0
	Definición de recursos y presupuesto solución (10 puntos)	6,5	6,0
INNOVA	Uso de tecnologías en la solución (5 puntos)	3,4	4,0
	Innovación en la solución (10 puntos)	6,8	6,0
BIENESTAR	Cobertura de la solución (5 puntos)	3,2	3,0
	Metas del proyecto (5 puntos)	3,7	4,0
	Impacto de la solución al Bienestar estudiantil (10 puntos)	7,2	6,0
VIABLE	Uso eficiente de recursos (5 puntos)	3,6	3,0
	Armonización con las políticas de la IED y su PEI (5 puntos)	3,8	4,0
	Relación con las 3 áreas de bienestar estudiantil (5 puntos)	3,6	3,0
	TOTAL	69,0	64,0

	Criterios/Proyectos	Media Ronda 1	Media Ronda 2
INGENIERIA	Definición del problema (10 puntos)	8,8	8,5
	Diagrama solución (10 puntos)	8,2	6,8
	Descripción metodológica de la implementación (10 puntos)	7,8	7,0
	Cálculos técnicos de la solución (10 puntos)	7,0	5,7
	Definición de recursos y presupuesto solución (10 puntos)	8,2	7,7
INNOVA	Uso de tecnologías en la solución (5 puntos)	4,3	2,8
	Innovación en la solución (10 puntos)	8,3	6,7
BIENESTAR	Cobertura de la solución (5 puntos)	3,8	3,5
	Metas del proyecto (5 puntos)	4,0	3,7
	Impacto de la solución al Bienestar estudiantil (10 puntos)	8,3	8,3
VIABLE	Uso eficiente de recursos (5 puntos)	3,7	4,2
	Armonización con las políticas de la IED y su PEI (5 puntos)	4,0	4,3
	Relación con las 3 áreas de bienestar estudiantil (5 puntos)	4,2	3,8
	TOTAL	80,7	73,0

Table 9. (a) Mean of the twenty-one projects of first round and (b) mean of the six projects of second round.

From the first round, the projects with the best score and passing to the second round were projects 8, 11, 12, 13, 14 and 17, with scores of 77, 88, 75, 85, 77 and 82 points respectively, exceeding the mean (69/100) of the other projects (see Table 9, a). Additionally, from the first round, the criterion of lowest mean score was the criterion Technical calculations with a mean of 5.8 points. This criterion is one of the distinguishing characteristics of any engineering project, and it is also the ability of an engineer to apply the knowledge of mathematics. Similarly, the criteria with a score lower than 7/10 or 3.5 / 5 were the diagram (6.9 / 10), resources and budget (6.5 / 10), use of technologies (3.4 / 5), innovation (6.8 / 10) and coverage (3.2 / 5). Given the importance of these criteria, it is important to emphasize in explaining them more clearly to the volunteer engineers and the participating students in the 2018 IBE challenge.

The total score awarded by the jury to the six best projects decreased from 80.7 points in the first round to 73 points in the second round (see Table 9.b), which shows that in the second round the jury had greater rigor to evaluate each of the criteria of the evaluation matrix. From the second round, the three best scores obtained by projects 8, 13 and 14 were 85, 84 and 82 points respectively, exceeding the mean of the total score of the six projects of the second round (73).

3.5 Survey of perception

In the sociodemographic factors (see figure 9), 43% of the participating students were ninth grade, 67% were female and 67% were stratum 2. From the above, the prevalence of the female gender took place by the constant accompaniment that the directives of the Menorah Women's College made to their students throughout the challenge, which allowed to present better results and therefore be 9 of the 21 finalists of the challenge.

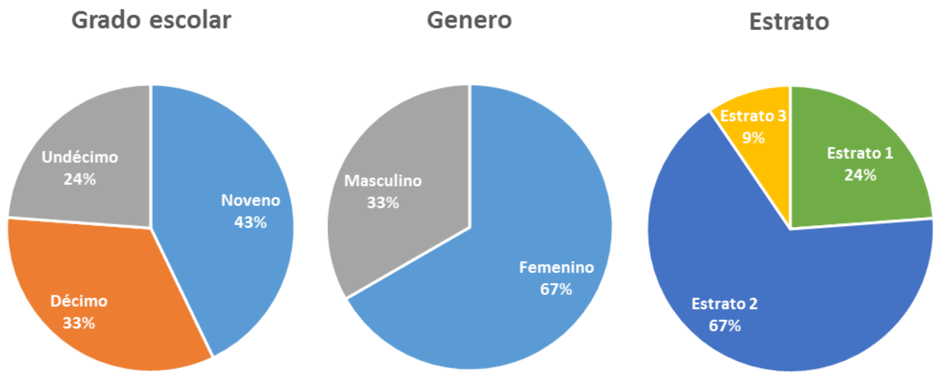


Figure 9. Sociodemographic factors of the survey.

The results of the response variable "Influence of the IBE Challenge" were obtained from the second part, which obtained a mean of 3.92 points, that is, in 78.4% the IBE challenge influenced the students' interest, their learning, their self-efficacy and their professional orientation by Engineering (see Table 10). The highest means are related to the promotion of interest and the incidence in professional orientation, with means of 4.14 points and 4.10 points respectively. However, the lower mean with 3.67 points was associated with the development of the idea converted into a project, which makes it necessary to strengthen the project formulation process, where the volunteer engineer's support is required to transform the student's idea in a viable project.

Variable de respuesta: Influencia del reto IBE	¿En qué grado el reto IBE promovió su interés por la ingeniería?	¿En qué grado el reto IBE facilitó su aprendizaje sobre la ingeniería?	¿En qué grado el reto IBE favoreció el desarrollo de su idea convertida en un proyecto de Ingenierìa?	¿En qué grado el reto iBE incidió en su orientación profesional?	PROMEDIO
MEDIA (sobre 5 puntos)	4,14	3,76	3,67	4,10	**3,92**

Table 10. Means of the response variable Influence of the IBE challenge,

From the third part of the survey, the results of the response variable "Indicators of interest in engineering" can be evidenced, which had 3.95 points, that is that in 79% the students consider that engineering is an attractive, remunerated and prestigious profession (see Table 11). From this, the highest mean (4.14 points) is associated with the perception of engineering as a prestigious profession, while with the same mean of 3.86 points is the perception of engineering as an attractive and remunerated profession.

Variable de respuesta: Indicadores de interés	¿Considera que la Ingeniería es una profesión atractiva?	¿Considera que la Ingeniería es una profesión remunerada?	¿Considera que la Ingeniería es una profesión prestigiosa?	PROMEDIO
MEDIA (sobre 5 puntos)	3,86	3,86	4,14	**3,95**

Table 11. Means of the response variable Indicators of interest.

4 Conclusion

Many student proposals were related to the theme of Healthy Lifestyles, which also includes school feeding, physical activity and recreation. This prevalence makes necessary to reinforce the themes of school mobility and risk management in the induction of volunteer engineers and in the announcement phase in the IEDs, to obtain a greater diversity of projects.

In the evaluation phase, specifically in the first round, the criterion with the lowest mean was Technical calculations (mean 5.8 / 10), that is, students and volunteers did not make explicit the application of knowledge in mathematics for the design and implementation of the solution. This criterion must be reinforced in the induction of the volunteers to transmit it to the students in the projects formulation phase.

Additionally, to make more personalized the accompaniment of the volunteer engineer with the student of middle school, it is necessary to recruit a greater number of volunteers of different engineering, to provide a better experience of professional orientation and to promote engineering as a higher education option. The engineering identified as transversal to the three themes of the PIBES are Industrial Engineering and related (production and administrative engineering), chemical engineering and related (process, food and petroleum engineering), computer engineering and related (software engineering), mechanical engineering (mechatronic engineering), civil engineering and related (transport engineering), environmental engineering and related, electronic engineering and related (electrical engineering) and biomedical engineering and related (bioengineering).

Finally, the perception survey allows a diagnosis of the influence of the challenge and students' interest by engineering. The mean of each response variable is close to 80%, that is a favorable perception of the challenge. However, there are indicators with less perception that should be reinforced through the challenge in the projects formulating phase, so that the challenge facilitates the idea development turned into an engineering project.

5 References

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Production System of the company Águas do Imperador

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Abstract

This study integrates a more comprehensive research, called here a major research, whose central question is: How to apply the Project Based Learning (PBL) approach in an undergraduate course in production engineering? He presents the application of the PBL approach in the discipline Introduction to Production Engineering, given in the first period of the undergraduate course of the School of Engineering of Petrópolis, Federal Fluminense University. In the context of a case study, the PBL approach was used for the planning and execution of a research project to study the operation of the production system of the company Águas do Imperador. The company is responsible for the water supply, collection and treatment of sewage in the city of Petrópolis. Initially, a bibliographical research was carried out on the subject of production system and sub-areas of Production Engineering. The study can be classified as exploratory using the case study as an approach. Next, a field survey was conducted to collect primary information about these topics in the partner organization through interviews with company employees. The result of the study was the detailed description of the operation of the production system of the partner company that together with the bibliographic research made possible an analogy of how the theoretical models studied fit the analyzed company.

Keywords: Active Learning; Engineering Education; Project Approaches.

Sistema de Produção da empresa Águas do Imperador

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Resumo

Esse estudo integra uma pesquisa mais abrangente, chamada aqui de pesquisa maior, cuja a questão central é: Como aplicar a abordagem *Project Based Learning* (PBL) em um curso de graduação de engenharia de produção? Ele apresenta a aplicação da abordagem PBL na disciplina Introdução à Engenharia de Produção, ministrada no primeiro período do curso de graduação da Escola de Engenharia de Petrópolis da Universidade Federal Fluminense. No âmbito de um estudo de caso, a abordagem PBL foi utilizada para o planejamento e execução de um projeto de pesquisa para estudar o funcionamento do sistema de produção da empresa Águas do Imperador. A empresa é responsável pelo abastecimento de água, coleta e tratamento de esgoto na cidade de Petrópolis. Inicialmente, foi realizada uma pesquisa bibliográfica sobre o tema sistema de produção e das subáreas da Engenharia de Produção. O estudo pode ser classificado como de natureza exploratória utilizando o estudo de caso como abordagem. Em seguida, foi realizada uma pesquisa de campo para coletar informações primárias sobre esses temas na organização parceira através de entrevistas feitas com os funcionários da empresa. O resultado do estudo foi a descrição detalhada do funcionamento do sistema de produção da empresa parceira que junto com a pesquisa bibliográfica possibilitou uma analogia de como os modelos teóricos estudados se encaixam na empresa analisada.

Palavras-chave: Active Learning; Engineering Education; Project Approaches.

1 Introdução

O curso de engenharia de produção da Universidade Federal Fluminense (UFF) em Petrópolis iniciou suas atividades em novembro de 2015. O currículo do curso utiliza a concepção metodológica da Aprendizagem Baseada em Projetos (*Project Based Learning* - PBL) e foi estruturado de forma a privilegiar a atividade de projeto (UFF, 2014).

Na Aprendizagem baseada em Projetos (*Project Based Learning* - PBL), problemas reais são solucionados por projetos. Assim, conhecimentos são adquiridos à medida que se evolui no planejamento e execução do projeto. Essa forma de aprendizagem permite que os alunos adquiram novos conhecimentos de maneira autônoma e à medida que executam o projeto desenvolvido para resolução do problema (Christie & de Graaff, 2017; Silveira, 2008). A abordagem PBL foi aplicada na disciplina Introdução a Engenharia de Produção do primeiro período do curso com o objetivo de os alunos conhecerem como funciona um sistema de produção na teoria e na prática.

Os alunos da disciplina tiveram como objetivo analisar empresas na cidade de Petrópolis e responder a seguinte pergunta: como funciona um sistema de produção sustentável e mais limpo? Para responder a essa pergunta, os alunos realizaram pesquisas bibliográficas sobre os principais temas da engenharia de produção, sempre procurando relacionar o assunto da pesquisa com a sustentabilidade. A parte prática do estudo foi realizada no âmbito de um estudo de caso com diversas empresas da cidade. Este grupo ficou responsável pela empresa Águas do Imperador, encarregada pelo gerenciamento do sistema de água e esgoto do município de Petrópolis. Visitas técnicas e entrevistas foram realizadas para melhor conhecer o funcionamento da empresa e uma comparação dos dados coletados foi feita com a teoria adquirida pela pesquisa bibliográfica.

As etapas realizadas para a conclusão do projeto serão explicitadas nos itens seguintes. No item 2 será apresentada a metodologia de pesquisa empregada no decorrer da disciplina. No item 3 é apresentado o funcionamento do sistema de produção da empresa em estudo. No item 4 são apresentadas as conclusões do estudo e considerações para pesquisas futuras.

2 Metodologia

A aplicação da abordagem PBL foi realizada na disciplina Introdução à Engenharia de Produção e para responder a seguinte questão de pesquisa: Como funciona o sistema de produção da empresa Águas do Imperador?

Para responder à questão proposta, os alunos elaboraram um projeto de pesquisa contendo os objetivos e justificativa da pesquisa, a metodologia para realização da pesquisa bibliográfica e da pesquisa de campo e o cronograma proposto. Utilizando a taxonomia de Cauchick (2012), a pesquisa foi classificada como de natureza exploratória, utilizando a abordagem de estudo de caso e com base em dados e métodos de natureza qualitativa.

A unidade de análise foi a empresa Águas do Imperador, concessionária controlada pelo Grupo Águas do Brasil que recebeu uma subconcessão da Companhia Municipal de Desenvolvimento de Petrópolis (COMDEP) para operar, conservar, manter, modernizar e ampliar os sistemas de água e esgoto. A concessão iniciou em 1998 e tem o seu término previsto em 2027. A empresa atende cerca de 280.000 habitantes e conta com 7 estações de tratamento de água e 25 estações de tratamento de esgoto e conta com mais de 106 mil ligações de água e esgoto. A busca pelas referências bibliográficas foi realizada em livros e artigos publicados em periódicos e anais de congresso. As referências foram organizadas no Mendelley® e priorizadas utilizando o software Excel®. Os tópicos mais importantes de cada referência foram destacados para facilitar os estudos dos demais integrantes do grupo, permitindo assim, uma difusão do conhecimento entre todos os membros do grupo.

Na pesquisa de campo, o grupo foi dividido em pequenos subgrupos, sendo delegado tarefas aos participantes de modo que se cumprisse o cronograma estabelecido no início da disciplina. Em seguida, foi realizado contato com a empresa, sendo então agendada uma reunião onde foi realizada a coleta os dados. Os dados foram coletados utilizando a observação, um questionário para os funcionários, anotações sistemáticas, fotos, dados no *site* da empresa, visitas técnicas e palestras sobre o programa de sustentabilidade da empresa. Foram realizadas duas visitas técnicas na empresa em estudo, uma na Estação de Tratamento de Esgoto (ETE) e a segunda na sua sede administrativa.

No final do período, cada grupo apresentou seu trabalho na forma de um seminário para toda a turma de Introdução a Engenharia de Produção. Nos seminários apresentados viu-se como as empresas em estudo aplicam as teorias das mais diversas áreas da Engenharia de Produção e como eles utilizam os conceitos de sustentabilidade em todos esses temas.

O método de avaliação da disciplina consistiu na avaliação, por parte do professor, do seminário apresentado juntamente com o relatório entregue contendo todos os dados colhidos na pesquisa bibliográfica e de campo, bem como uma avaliação individual de cada aluno de acordo com o seu desempenho na apresentação do seminário e dos comentários feitos pelo gerente de sua equipe. O gerente da equipe avaliou o desempenho de cada integrante de seu grupo durante o decorrer da disciplina. Cada aluno também avaliou o desempenho de seus colegas de equipe por meio de questionários, bem como a atuação de seu gerente. Essa forma de avaliação prepara o aluno para o ambiente do mercado de trabalho, em que ele será constantemente avaliado pelos seus companheiros de trabalho e por seus superiores.

3 Estudo de caso

Um sistema de produção é o conjunto de atividades e operações inter-relacionadas envolvidas na produção de bens ou serviços. A função de um sistema de produção é a satisfação de clientes através da provisão de bens e serviços que possuam alguma utilidade (Slack & Chambers & Johnston, 2010).

O sistema de produção da Águas do Imperador pode ser dividido em cinco partes: captação da água, tratamento, distribuição, captação de efluentes e por fim tratamento dos efluentes. O sistema de produção da empresa em estudo é apresentado na Figura 1.

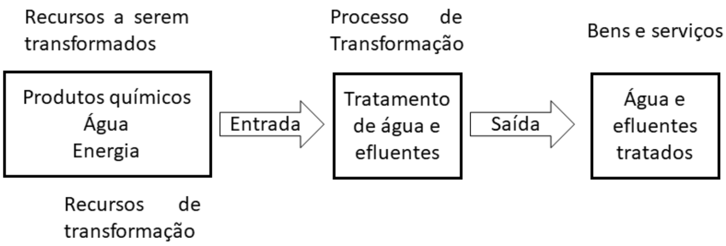

Figura 48. Sistema de Produção da Águas do Imperador. Fonte: adaptado de Slack & Chambers & Johnston, 2010.

A empresa em estudo, por se tratar de uma subconcessão, é limitada a prestar serviços apenas para a Prefeitura Municipal de Petrópolis, sendo assim sua única cliente. Devido a isso, a Águas do Imperador tem dois principais Sistemas de Produção, o da Estação de Tratamento de Água (ETA) e o da Estação de Tratamento de Esgoto (ETE). Tais sistemas apresentam o tipo de Sistema de Produção Contínua, pois funciona todos os horários e dias da semana, apesentando maiores picos no consumo em horários como 12h00min e 18h00min.

Falando especificamente do tratamento de água, o processo é bem simples e feito da forma (vide Figura 2):

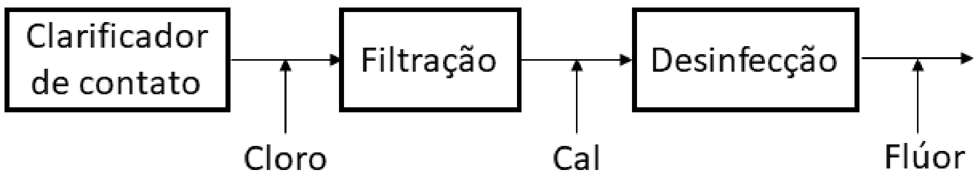

Figura 2. Estação de Tratamento de Água (ETA). Fonte: elaborado pelo autor.

O processo da ETA inicia-se com a captação da água a qual passa por um processo de gradeamento para a remoção de sólidos grosseiros. Após isso, ocorre um processo chamado coagulação, que utilizam coagulantes e polímeros, fornecidos pela Bauminas Química Ltda., devidamente dosados para que as impurezas se transformem em partículas que serão removidas nos processos seguintes. Com a facilitação em identificar as impurezas, o processo de floculação vem a seguir. Esse processo é responsável pelo agrupamento e compactação das partículas em suspensão, formando blocos. Essa formação de blocos faz com que ocorra a clarificação da água após o processo de decantação, mediante a sedimentação da matéria coagulada. A remoção das impurezas ocorre no processo de filtração, que elimina as matérias em suspensão, germes, bactérias e microrganismos após a passagem por um sistema composto por: carvão ativado, areia e cascalho, que atuarão como uma peneira na retenção das impurezas. Esses agentes da filtração são fornecidos pela Unipar Carbocloro, além de outros materiais como cloro e flúor. Com a água já filtrada, passa-se por uma câmara de contato, onde ocorrem os processos de fluoretação, cloração e alcalinização. O primeiro provém da adição de flúor com o objetivo de prevenir cáries dentárias. Já a cloração é a operação final do tratamento purificador, que tem como finalidade desinfetar a água, eliminando os mais diversos tipos de microrganismos patogênicos.

O último processo consiste no controle de pH, corrigindo a acidez natural ou adquirida por efeito do tratamento coagulante. Após todo o tratamento da água, a mesma é bombeada até reservatórios, com o auxílio de elevatórias, estando a água pronta para a utilização. A distribuição ocorre pelo próprio sistema de encanação para as casas, onde, caso haja uma dificuldade na chegada da água (por conta da altura, por exemplo) *boosters* são utilizados para que a água tratada chegue às moradias com tal empecilho.

Já o Tratamento de Esgoto tem um processo mais complexo, uma vez que o tratamento é mais intenso. O processo começa com um gradeamento para a retirada de sólidos grosseiros, tais como sacos plásticos e lixo em geral. Em seguida, o esgoto passa por uma caixa de areia para a retirada de grãos e outros sólidos de pequeno tamanho para evitar a abrasão de equipamentos. Com a retirada dos resíduos sólidos, o tratamento passa por diferentes tipos de reatores biológicos, que por meio de diferentes bactérias, consomem a matéria orgânica do esgoto. São três os tipos de reatores que fazem esse processo: o aeróbio, o anaeróbio e o anóxico. No reator aeróbio as bactérias aeróbias, que através de aeração do meio líquido, consomem até 60% da matéria orgânica do esgoto. São também muitas vezes utilizadas para polir o efluente após o tratamento anaeróbio, mas também podem ser a única etapa do tratamento biológico. O reator anaeróbio, também chamado de leito de bactérias, é composto por bactérias anaeróbias (não respiram oxigênio) que consomem até 70% da matéria orgânica do esgoto e produzem o gás metano, que é altamente inflamável. O terceiro tipo de reator, o anóxico, consiste no uso de bactérias aeróbias, que na ausência de oxigênio liberam o nitrogênio do meio líquido. Essa operação não é necessária na maioria das ETEs. Após esse consumo biológico da matéria orgânica, o esgoto passa por um decantador, onde ocorre a retirada dos sólidos sedimentáveis remanescentes do tratamento. Com isso o esgoto tratado termina o processo, sendo então despejado em um corpo receptor. Uma síntese do processo pode ser vista na figura 3.

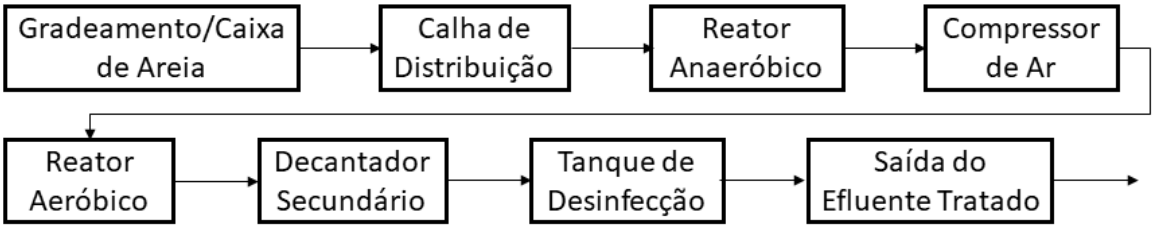

Figura 3. Estação de Tratamento de Esgoto (ETE). Fonte: elaborado pelo autor.

Após esse tratamento realizado na ETE, a água obtida está com cerca de 95% de pureza em relação ao que foi recebido pela captação. Essa água é utilizada para limpar calçadas, regar parques públicos e pode ser retornada as ETAs (Estação de Tratamento de Água) para se tornar consumível de novo.

Todos os tipos de água utilizada nas residências retornam para a Águas do Imperador em forma de esgoto, o que nos leva ao tratamento dessa água já utilizada.

Mesmo ambos os tratamentos possuindo caráter de cadeia produtiva, dentre todas as etapas é possível verificar a importância de cada passo para a realização de todo o processo que pode ser observado da seguinte forma na figura 4:

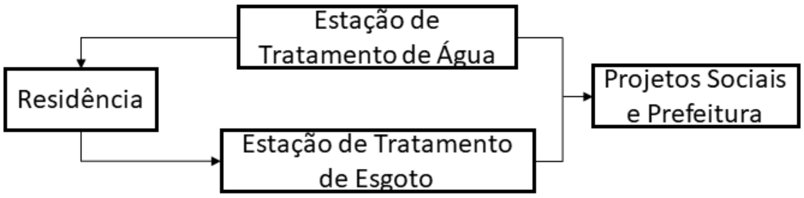

Figura 4. Distribuição da Água aos Consumidores. Fonte: elaborado pelo autor.

As informações exibidas foram coletadas através de entrevistas com funcionários e visitas técnicas realizadas nas dependências da empresa. Para responder à pergunta que norteia este projeto, que é: como funciona um sistema de produção sustentável e mais limpo, foram realizadas comparações com o que foi levantado pela pesquisa bibliográfica com as informações coletadas na pesquisa de campo.

A empresa em estudo segue diversos critérios com relação ao meio ambiente, como a escolha de fornecedores devidamente regularizados perante os órgãos de fiscalização ambiental. Diversas licenças devem ser obtidas para que a empresa possa operar, como as licenças fornecidas pela Polícia Federal, Secretaria Ambiental de Petrópolis, Secretaria de Estado do Ambiente e do Instituto Estadual do Ambiente.

O tratamento de esgoto utilizado pela empresa não emprega produtos químicos, sendo o processo regido por microorganismo, tornando o processo como um todo sustentável, ao analisarmos o fato de que essa operação não gera resíduos nocivos ao ambiente, pelo contrário, as bactérias descartadas dessa operação podem ser utilizadas como fonte de matéria orgânica em plantações. No que se refere ao tratamento da água para consumo, o fato da empresa em estudo produzir seu próprio cloro utilizado no tratamento, reduz significativamente os riscos de manuseio e transporte desse produto altamente corrosivo e tóxico, evitando assim o risco de acidentes durante o seu transporte das fontes produtoras até as unidades de consumo da empresa.

Enquanto subconcessão de um serviço público, a empresa Águas do Imperador deve seguir um conjunto de normas e exigências que são determinadas no edital de licitação. No caso de serviço de saneamento e tratamento de água, a empresa deve seguir o Plano Municipal De Saneamento Básico (PMSB). Todas as melhoras de infraestrutura e expansão das áreas de tratamento devem seguir o PMSB e as atividades exercidas pela empresa são limitadas as atividades predefinidas pelo edital de licitação.

O grupo Águas do Brasil, enquanto acionista majoritário da empresa Águas do Imperador, participa ativamente na formulação e na revisão da estratégia de produção da empresa. Cada setor da empresa repassa as demandas e os relatórios das operações executadas para o setor administrativo. Depois de analisar as operações e as demandas, a diretoria da empresa discute junto à diretoria do grupo Águas do Brasil, as questões estratégicas e como elas podem modificar o comportamento estratégico para alcançar melhor os objetivos. Considerando isso, a empresa formula sua estratégia tanto de cima para baixo (*top-down*), quanto de baixo para cima (*bottom-up*).

Como a atuação da empresa é limitada pelo Plano Municipal De Saneamento Básico (PMSB), os objetivos de desempenho são estipulados pela legislação, como por exemplo a qualidade, velocidade, e a confiabilidade. Além disso, o preço cobrado aos consumidores também é determinado pela lei. O tratamento de água e esgoto é executado continuamente, mas as operações de manutenção e ligações novas têm um prazo determinado pela legislação. Geralmente essas operações são executadas antes mesmo do vencimento do prazo, garantindo assim alta confiabilidade e evitando desperdícios por parte da empresa. A flexibilidade está presente na maioria das operações. No tratamento de água pode-se analisar a flexibilidade nos processos de tratamento, já que eles estão sempre estudando a composição da água a ser tratada e dependendo das concentrações químicas, os procedimentos, as substâncias e suas dosagens usadas no tratamento serão alterados. Além do tratamento, a flexibilidade também está presente nas outras operações, já que podem ocorrer diversas condições adversas de clima ou nas relações com os clientes. De modo geral, por se tratar de um serviço essencial, os objetivos de desempenho têm como função basicamente atender os parâmetros, já que os consumidores não irão consumir mais nem menos em função desses objetivos. Sendo assim, a perspectiva de mercado não tem muita relevância na estratégia de produção da empresa.

Considerando que o preço cobrado pela água e pelo esgoto tratado deve seguir as normas do edital da licitação, para aumentar a lucratividade da empresa o melhor caminho seria reduzir os custos de produção e os outros gastos. Apesar dessa diminuição nos gastos ser efetiva para maximizar o lucro, ela é limitada pelo contrato de concessão, pois ele estipula um valor de lucro ao longo do tempo e se o lucro for muito maior do que o estipulado é feita uma redução na taxa cobrada aos usuários, do mesmo modo se a empresa tiver um lucro bem menor do que o estipulado é feito um aumento na taxa cobrada aos usuários.

Já que a empresa não precisa se esforçar para agradar a perspectiva do mercado, nem pode aumentar consideravelmente seus lucros, a estratégia de produção da empresa deve se concentrar em realizar as melhorias estruturais contidas no PMSN e as funções de tratamento de água e esgoto adequadamente, mantendo sua lucratividade dentro do estipulado e visando a perspectiva dos recursos da empresa.

No que diz respeito a redução de custos de produção e na administração eficiente dos recursos, pode-se destacar algumas práticas, como a implementação recente de um processo de obtenção do cloro para tratar a água, através do cloreto de sódio, o sal de cozinha. Originalmente o cloro era comprado com um fornecedor, mas além de mais caro, o procedimento de transporte do cloro é complicado já que ele apresenta altos riscos. O uso de biodigestores nas regiões de difícil acesso, onde seria difícil montar o sistema de coleta de esgoto reduz os custos com o transporte do esgoto até uma estação de tratamento. Com os biodigestores, a empresa consegue tratar o esgoto dessas regiões de forma eficiente atendendo todos os parâmetros do PMSB e mesmo não cobrando os usuários do esgoto tratado pelos biodigestores, a empresa ainda economiza no capital que ela iria ter que gastar na construção de ETEs e na rede de esgoto.

A empresa está estudando usar os gases, gerados pelo tratamento anaeróbico do esgoto, para a produção de energia que abasteceria a estação inteira. Apesar de esse projeto economizar dinheiro gasto com a compra de energia elétrica, ainda está sendo realizado um estudo pela empresa para analisar o custo da construção desse sistema e também do risco de estocar esse gás, o metano, altamente inflamável e que atualmente é queimado nos *flares* das estações.

A natureza do Programação, Planejamento e Controle da Produção (PPCP) muda ao longo do tempo, podendo ela ser de longo, médio ou curto prazo (Tubino, 2000). No PPCP de longo prazo, é planejado o que se pretende fazer, que recursos precisam e quais os objetivos esperam-se atingir onde, nessa natureza, não há muito controle. O de médio prazo possui mais detalhes e pretende analisar a demanda global que a organização precisa atingir de forma parcialmente desagregada. O de curto prazo já possui muitos dos recursos definidos e dificilmente possui mudanças de grande escala.

Os principais processos executados pela empresa Águas do Imperador são o tratamento de água e o tratamento de esgoto. Ambos esses processos são contínuos e ocorrem 24 horas por dia. O PPCP deve garantir que esses processos não sejam interrompidos já que a todo instante os habitantes da cidade estarão utilizando água e produzindo esgoto.

Apesar do processo de tratamento de água e de esgoto acontecer continuamente, existem horários em que a taxa de consumo de água e de geração de esgoto são maiores, logo as estações devem armazenar nos reservatórios um nível de água suficiente para atender a demanda desses horários de pico de consumo de água tendo também que aumentar a vazão de esgoto que irá adentrar nas ETE para ser tratado. Além de planejar os níveis diários a empresa também estuda o consumo em diferentes épocas do ano, por exemplo, no inverno o consumo de água é substancialmente menor do que o resto do ano, então as estações irão planejar fornecer uma quantidade menor de água, e consequentemente tratar uma quantidade menor de esgoto. A legislação de consumo de energia, determina que nos horários de 18h até 20h, que é o horário de pico do consumo de energia, as indústrias possuem um limite de uso de energia elétrica, logo a as estações de tratamento devem se planejar para realizar uma quantidade maior de trabalho durante os outros horários.

Localizado na ETE do Palatinato, a empresa possui um Centro de Controle Operacional (CCO), onde nesse centro é possível observar todos os níveis de água e esgoto das estações, o fluxo de água e esgoto, a pressão nos canos, a vazão das estações e se o funcionamento desses sistemas está adequado. Além de permitir observar esses dados, o CCO permite um controle eficiente dessas operações. Quando o reservatório de uma estação chega ao seu limite e a perspectiva de consumo daquele reservatório é menor do que a vazão de entrada de água, o CCO transfere parte da água para outra estação onde o reservatório está mais vazio. Quando o CCO observa que a pressão em determinado tubo está menor do que o adequado, ele aciona um *booster*, que aumenta a pressão do tubo fazendo a água chegar ao destino correto. Além desses exemplos, o CCO é o responsável pelo controle da maioria dos processos de distribuição e armazenamento da água e esgoto, o que é essencial para o PPCP.

Outra operação fundamental para a empresa é a manutenção dos sistemas. A manutenção interna de uma estação de tratamento deve ser realizada em um tempo mínimo já que a falta da mesma pode acarretar em falta de fornecimento de água ou acúmulo de esgoto. No caso das ETAs, além do tempo de ociosidade da estação durante a manutenção, é necessário bastante tempo para pressurizar a água para que ela chegue até o destino. Algumas estações de água ou esgoto são divididas em duas, desse modo elas podem continuar operando durante uma manutenção, porém com capacidade reduzida. As manutenções externas às estações são executadas durante o dia todo e obedece principalmente a três critérios: ao tamanho do reparo a ser realizado, os reparos onde há maior vazamento de água ou esgoto ou podem causar maiores danos são a prioridade; solicitação da prefeitura, a prefeitura costuma solicitar reparos frequentemente à empresa; ordem cronológica de solicitação, assim que um usuário dos serviços liga para a central para solicitar reparo, a empresa tenta realizar o reparo o mais rápido possível.

4 Conclusão

A metodologia PBL aplicada na disciplina de Introdução a Engenharia de Produção teve como objetivo permitir aos alunos conhecerem como funciona na prática um sistema de produção. Essa metodologia será aplicada em todo o decorrer do curso de Engenharia de Produção da Universidade Federal Fluminense da cidade de Petrópolis.

O sistema de produção da empresa pode ser dividido em cinco partes, que são captação da água, tratamento, distribuição, captação de efluentes e por fim tratamento dos efluentes. O planejamento e controle da produção é realizado numa sala de controle na estação do Palatinato, permitindo assim o monitoramento do abastecimento de toda a cidade, 24h por dia sem interrupção.

O produto da Águas do Imperador é na verdade um serviço, no caso o tratamento da água e de efluentes. Com isso, o desenvolvimento do produto seria o próprio processo de tratamento, com a busca de sempre aumentar a qualidade dos serviços prestados nas estações de tratamento, sempre garantindo a entrega da água que atenda aos requisitos impostos pela legislação do setor.

A Águas do Imperador segue diversos critérios sobre a escolha dos fornecedores regulamentados por órgãos ambientais, o processo não emprega produtos químicos, sendo apenas regido por microorganismos. O fato de a empresa produzir seu próprio cloro reduz os riscos desse produto altamente corrosivo e tóxico, evitando assim o risco de acidentes durante o seu transporte das fontes produtoras até as unidades de consumo da empresa.

A metodologia PBL agrega uma nova maneira dos estudantes agregarem conhecimento. Nessa metodologia, os alunos deixam a forma passiva de receber de conhecimento de seus professores e passam busca-lo para resolver os problemas apresentados. Com isso, forma-se profissionais mais independentes e capazes de lidar com as dificuldades do mercado de trabalho.

O trabalho proporcionou uma grande interação entre os alunos e a empresa, possibilitando assim a criação de uma futura cooperação entre a empresa e a universidade na realização de parcerias na realização de pesquisas e estágios para os alunos da instituição.

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A Multidisciplinary Extension Project for Children and Teenagers Logical Reasoning Development in an Engineering Context

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Abstract

This paper presents an analysis of a University Extension Project which offers programming and electronics notion to children and teenagers by using Arduino as a learning tool. The project promotes logical reasoning development and interest in technology to the audience. Moreover, social skills are improved through the classes, such as motivation, autonomy, leadership, initiative, and other skills. The project focuses on children in all social conditions, however, the main group is compound by teenagers of a public school in Belo Horizonte (Minas Gerais, Brazil), aged in a range between 14 and 16 years old. The positive outcomes of this project not only apply to the favored students but also the undergraduate students, members of the staff, since they were able to develop specific skills that classic engineering programs do not provide. The personal and professional sides were clearly improved on those involved in the project due to unique experiences they have lived that lead them to think about their social role in society. Thus, has been added a singular value to their engineering formation, through the interpersonal relation skills improvement, characteristic widely required in companies and industries selection programs.

Keywords: Education; University Extension; Arduino; Logical Reasoning.

1 Introduction

The academic performance of primary and secondary education in the exact sciences in Brazil has worried the education specialists due to results of assessment exams. These results have exposed the exact sciences as one of the least developed. The main National Indicator, the *Exame Nacional do Ensino Médio* (ENEM – High School National Exam), held in 2016, pointed out that students' scores in mathematics remained among the worst, being only ahead of the natural sciences (Ministry of Education, 2017). The average grade, which can vary from 0 up to 1000, of the participants who finished high school in 2016 in human sciences and their technologies was 536.0, languages and codes and their technologies 523.1, mathematics and its technologies 493.9 and natural sciences and their technologies 482.3. According to Maria Inês Fini, president of *Instituto Nacional de Estudos e Pesquisas Educacionais* (INEP – National Institute of Educational Studies and Researches), an organization linked to the Ministry of Education (MEC) responsible for the examination, the performance in all areas remained practically unchanged from 2008 to 2016.

International indicators have merged towards the same scenario. The results of the Program for International Student Assessment (PISA), held in 2015, which had 70 participating countries, ranked Brazil in the 66th position in mathematics, a drop of 8 positions since the last evaluation (Organisation for Economic Co-operation and Development - OECD, 2017). Indeed, Brazil worsened its indexes, since in the previous years the country was placed already among the last positions in mathematical rank. Moreover, according to PISA 2015, schools with low socioeconomic status are less likely to offer school activities involving science, such as clubs and competitions. Among the countries surveyed, socioeconomically disadvantaged students are about three times less likely to achieve the basic level of proficiency in science than those students with a socioeconomic advantage.

Thus, the current situation shows that Brazilian public policies on basic education have had little effect lately and have not contributed for the preparation of the future professionals who will be requested to have skills based in a well-reasoned logic development. This issue concerns the *Federação das Indústrias do Estado de Minas Gerais* (FIEMG – Minas Gerais Industrial Federation), which, through its president Dr. Olavo Machado Júnior, has shown its intention to foster the development of the technology-based industry in the state in the coming years. FIEMG initiatives such as the Entrepreneurial Engineer program and FIEMG Lab portray the implementation of the Federation's strategic planning (Federação das Indústrias do Estado de Minas Gerais, 2017). At a time when science learning is constantly linked to economic growth, the sense of urgency for developing these professional skills becomes a challenging framework for education authorities

Briefly, the problem situation is the lack of interest and the difficulty of the students from basic education to learn the contents in the exact sciences. Consequently, with this basic formation compromised, the students face difficulties in higher education in courses in exact areas. Statistics have shown that around 320 thousand students enroll in the engineering course per year, only 10% finish the course (JOURNAL OF SCIENCE, 2011, apud SANTOS 2012). One cause is how science is being taught in basic education. In fact, is outdated, teaching methodology does not attract the student. Thus, in order to modify this situation, innovative teaching methodologies have been proposed, such as gamification of studies when teaching mathematics. An example of this methodology is the Matific, a platform that contains about 100 thousand users. The platform has been presenting good results, their users have shown an improvement in their mathematical performance in a 70% increase. This paper presents another alternative methodology for learning by showing what has being done and also the outcomes. Finally, this paper aims to verify the feasibility of the project developed in a University Extension Project at the *Pontifícia Universidade Católica de Minas Gerais* (PUC Minas – Pontifical Catholic University of Minas Gerais), which aims to arouse, in children and teenagers of the public education grid, the interest in exact and technologies, by using Arduino as a programming learning tool as well as electronics, contributing directly to the formation of those mentioned.

2 Methodology

At PUC Minas, the Extension Pro-Rectory (PROEX) manages university extension projects. The university extension intends to reinforce the social function of PUC Minas, through the articulation of academy with society, by promoting citizenship, social inclusion and social development (Felippe, 2017). The Extension Pro-Rectory is composed by thematic units and the project presented in this paper is coordinated by Thematic Centre of Technology and Innovation (NUTEI) that aims to develop and transfer knowledge, technologies, innovative, adaptive and appropriate methodologies (Extension Pro-Rectory, 2017). The NUTEI’s guidelines aim to contribute to the progress of the activities of education, research and extension of the Polytechnic Institute (IPUC) of PUC Minas, in an inseparable and interdisciplinary way.

Annually, PROEX publishes an internal call for proposals of extension projects in various areas at PUC Minas. Proposals must describe the following project’s features: activities, objectives, purpose, methodology, staff number, costs, among others. Once approved, PROEX promotes a selection of students from the academic community. During the registration stage, students must define the projects that they are interested to be part. Afterward, the coordinator of each project selects suitable student profiles to fill in the available opportunities, this way the students become extensionists. The accepted proposals receive funds for the project’s planning execution, which might support the purchase of educational kits, financial assistance grants for extensionists and support the transport to travel to the course application place.

This university extension project, based on Arduino learning, has been receiving a large number of candidates. Recently a selection process had more than forty candidates. However, less than twenty students were selected due to the limit of opened positions. The student selection considers technical skills and level of interest, also multidisciplinary profiles, including students from engineering up to marketing. The knowledge dynamics flow by sharing the veterans’ experience with beginners and from lessons acquired during the project. Furthermore, there is also a first contact training for new members that allow them to familiarize with the classes that will be taught.

At the beginning of the semester, the selected students are allocated to workgroups accordingly to their skills and availability. The availability also defines their schedule, twenty or ten hours per week. The student can either receive a scholarship or be a volunteer, this is determined by the project's costs planning and coordinator's project. Usually, a designated student stays in the same group throughout the semester, collaborating to a relationship development between the staff members and students benefited, contributing to the citizen and humanist formation on those involved.

The project's costs' planning also considers the staff mobility, since the public-school site is distant from the university. Thus, cabs' vouchers are included in planning to guarantee that classes can be taught even the students benefited don't have conditions.

Concurrently, a material list previously defined by the classes contents, is requested to be purchased. The university's purchasing department intermediates the project's interests with suppliers to ensure that what is being purchased meets design demands. The project uses two different educational kits (Figure 1), both characterized by the staff.

Figure 1. Educational Kits: Arduino starter kit (left), Arduino kit part 1(middle) and Arduino kit part 2 (right).

The components of each kit are described below (Table 1):

Table 1. Educational kits' components.

Arduino Starter Kit
Introductory KIT Arduino (Arduino UNO, LEDs, sensors, resistors, breadboard, jumpers, etc.)
Ultrasonic sensor HC – SR04
DC Motor 5.9 V
H bridge L298N
Bluetooth Serial HC – 05
VGA Camera
Wi-Fi Module
Arduino Kit
Arduino UNO
Ultrasonic sensor HC – SR04
Acrylic cart chassis with four engines and four wheels
H bridge L298N
Bluetooth Module
Remote Control
Shield DC Motor
Batteries and adapters

Simultaneously, the project disclosure and the students benefited's selection is done at the public schools by the veteran extensionists and the coordinator. The selection method requests that each student write a letter of interest. The staff evaluates the letters searching for students who show aptitude, social needs, interest and/or willing to learn. Those who meet the requirements are invited to enroll in the classes.

Another key task is the lessons reviews. This task intends to improve lessons by using students' feedbacks after the classes, also by searching for errors on the material used to taught

After the internal project structuring, the classes start. The Arduino kits are used as learning tool to develop logical reasoning on children and adolescents by encouraging them to build projects with it, as Figure 2 presents. Thus, some daily life experiences are used to illustrate a problem to be solved, for example, traffic lights which control two streets flow rate. They are captivated to think using logical sequence while solving the problem, evolving their algorithms skills, and then increasing their programming skills.

Figure 2. Benefitted student building a project at a class (left) and exhibition day at the public school (right).

Thus, for quality purposes, during the semester the staff have tracked children and teenagers' motivation and the results pointed out that it is driven by the desire to learn, the challenge of learning something new, also to create something. Therefore, challenges are proposed every class, so that they can feel motivated to apply the concepts acquired during the classes. Moreover, at the end of the course, a final challenge is proposed to the students. They have to build up carts based on Arduino that dodges the obstacles in a track, respecting a time limit. It was noticed that this approach is extremely effective, since the students seek to create more efficient programs.

The classes use PowerPoint and visual resources to facilitate the comprehension. Software like Fritzing or Tinkercad has been providing tools to elaborate pleasant visuals of the electric circuits, turning them easier to understand. Theoretical and practical approaches are used on classes in a manner that all theoretical contents have to be fixed through practice.

At the end of each class, the students have to answer a form. The form has some questions that the extensionists use to retrieve the project performance indicators. Some examples of indicators are the classes' progress, other the student's interests on the subject taught. Those indicators are important because they expose lessons quality, also the personal development of the students.

Finally, at the end of the course, the staffs promote an exhibition of the projects developed by the students benefited at the public school. This exhibition main purpose is students' motivation through recognition of a well-done job and the project marketing aiming to attract new students.

3 Results and Discussion

In order to measure the influence of the lessons given by students in extension some assessment tools have been developed. The main one is a formulary containing fifteen questions and a logical challenge which is applied at the end of each lesson. This document is based on a series of multiple-choice questions, containing only four alternatives for each question, however, for more direct questions student should choose "yes" or "no" option.

Some indicators have been showing nuances of the Active Learning through the perspective of the benefited students, once they show the effectiveness and degree of receptivity of the classes. For example, Figure 3 presents graphics which point out how well the knowledge is been taught by measuring the benefitted student autonomy.

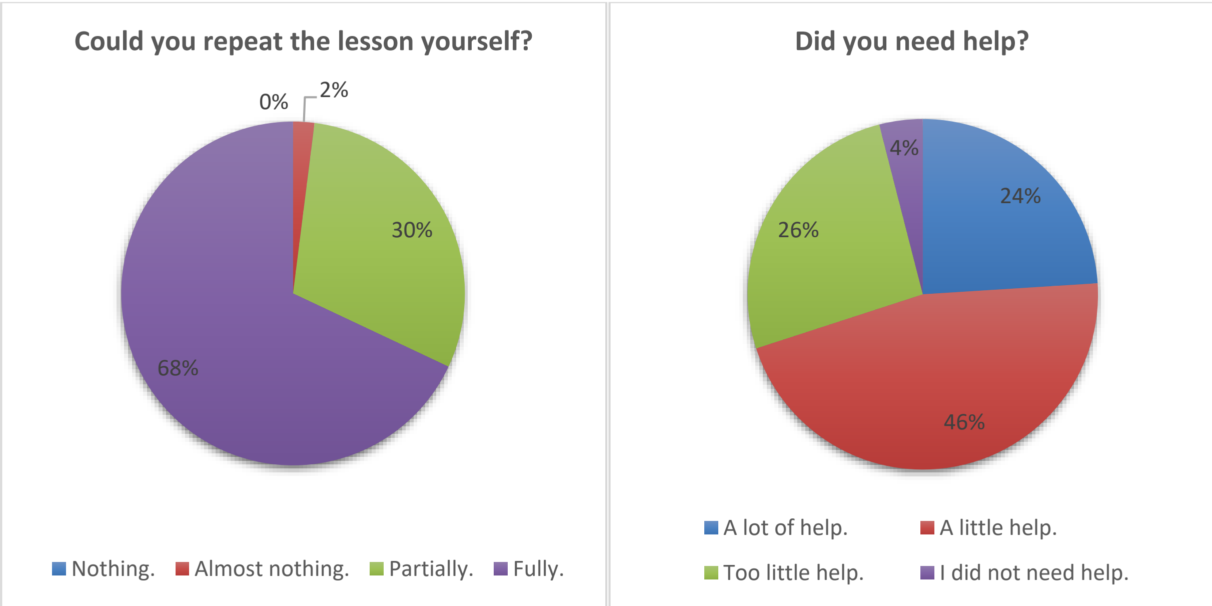

Figure 3. Autonomy Indicators

These first two graphics claims that 68% of the students could repeat the class individually, however, 96% of the students have shown some necessity of help. The staff noticed that by providing the necessary support, the benefited students are capable of accomplish the problems purposed in classes.

Another relevant indicator is why they come to class and Figure 4 shows the student's motivation levels.

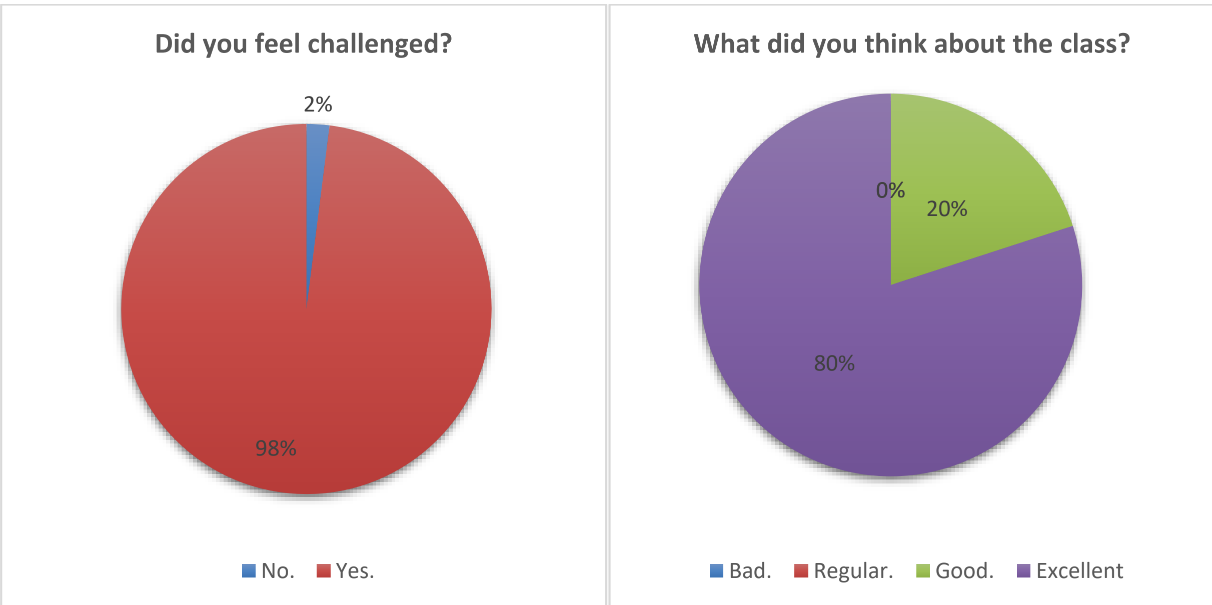

Figure 4. Motivational Indicators

One the main objectives of this project is motivation through challenging and the project has been showing a good response, as Figure 4 displays since 98% of the benefited students answered that they felt challenged in classes, also all the students have shown their satisfaction about the classes.

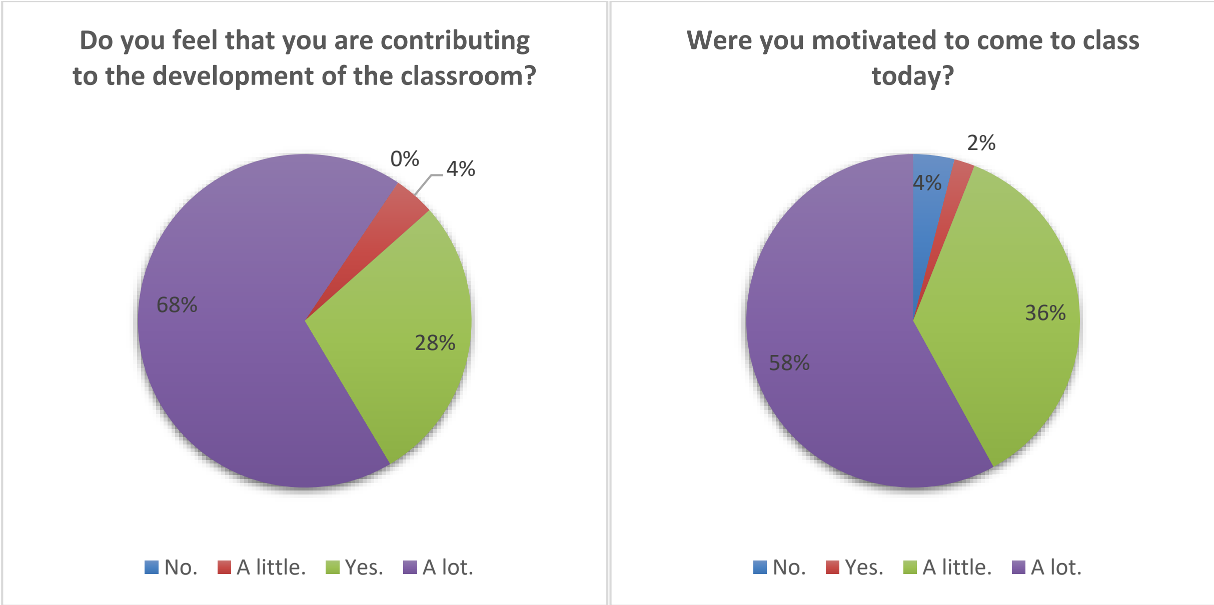

Figure 5. Personal Classes Feedback

Finally, Figure 5 presents how the dynamic classes enriched by discussions, between benefited students and staff have been promoting students' participation and also an increase in their interest. Moreover, 96% of students agree that they are actually contributing to the classroom development. At the same time, all students rated the classes at a good level. These data, besides demonstrating the classes' effectiveness, they also justify the high motivation of more than half of the room to go to the classroom.

4 Conclusion

It is interesting to notice that this project benefits not only the children and teenagers but also the undergraduates and the University. This fulfills the mission of the University Extension, which is the promotion of the articulation of academy with society.

In an academic context, an Extension Project shows a great effectiveness to make the engineering undergraduates' education more complete, in a humanistic and social point of view, contributing to the education of individuals who have a better understanding of their social role. This allows the University vocation to be fulfilled, which is, according to the Institutional Developing Plan (PDI) – PUC Minas (2011, p. 62), "(...) the formation of a student competent, scientific and technically, who know act with strong professionalism and responsibility in their area and, besides, who has behavior based on the ideals of justice and solidarity."

In addition, the Mechanical Engineering Undergraduate Program at PUC Minas has a course at the first term which contains Arduino programming and its applications as the main subject. The course is called Introduction to Mechanical Engineering. It is relevant to mention that there are some undergraduates which are coursing this subject as well compounding the project crew. Furthermore, it is visible how the university extension's experience is contributing to their formation, since they are having the experience of helping children and teenagers with contents their selves had recently.

The social skills that the undergraduate students developed with the project are one of the most expressive outcomes, training future professionals with skills that are very important in the job market, even in their personal life. Besides, the scientific thinking is acquired by them, which contributes for the development o the science. This is notable, once that the students involved with this project are also engaged with other researches and projects.

Finally, this project contributes to the development of logical reasoning and interest by technology of the benefited students. In a point of view of the Active Learning, it is possible to notice that there is a high receptivity of these students about this kind of learning.

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Integrated actions with active methodology to arouse the interest in the exact sciences area

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Abstract

In spite of the progress made in gaining women's space in the area of exact and in particular in engineering, the presence of women is still low compared to the presence of men. In order to diversify the fields of science, technology, engineering and mathematics, we must combat the stereotypes and prejudices that permeate society. It is in this context that the "Fast Girls" Project appears. This is an extension project of the University of Brasília, formed by undergraduate students of Engineering courses, as well as professionals in Psychology, Education and Sociology. The project aims to encourage high school students to opt for careers in the exact areas. The objective of this work is to present the methodologies used, based on group dynamics, hands-on experiments and problem-based learning (PBL), where concepts of Physics, Mathematics and Chemistry are presented in a playful and practical way. The active methodologies are used so that the students learn in a more autonomous and meaningful way. Actions related to the courses, the professions and the forms of entry and stay in the university are integrated. In addition, lectures are held to stimulate critical thinking, not only about women entering the exact areas, but also about their position in society. Reflections are reported on the results achieved regarding the application of methodologies, motivation for the area of exact and impact of the project in the school where it was applied and in the choices of the students.

Keywords: Gender equality, Active Learning; STEM.

Ações integradas a metodologias ativas para despertar o interesse na área de exatas

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Resumo

Apesar do avanço no que se refere à conquista de espaço das mulheres na área de exatas e, em particular nas engenharias, a presença feminina ainda é baixa comparada à dos homens. Para diversificar os campos da ciência, tecnologia, engenharia e matemática devem-se combater os estereótipos e preconceitos que permeiam a sociedade. É nesse contexto que surge o Projeto Meninas Velozes, um projeto de extensão da Universidade de Brasília, formado por estudantes e professoras de graduação dos cursos de Engenharia, Psicologia, Educação e Sociologia. O projeto tem como propósito incentivar as alunas do ensino médio a optarem por carreiras nas áreas de exatas. Neste trabalho são apresentadas as metodologias utilizadas apoiadas em dinâmicas de grupo, experimentos do tipo "hands on" e aprendizagem baseada em problemas (PBL), onde conceitos da Física, da Matemática e da Quimica são colocados de maneira lúdica e prática. As metodologias ativas são utilizadas para que as alunas aprendam de forma mais autônoma e significativa. São integradas ações relacionadas aos cursos, às profissões e às formas de entrada e permanência na universidade. Além disso, são realizadas palestras com intuito de estimular o pensamento crítico, não apenas sobre o ingresso de mulheres nas áreas exatas, mas também sobre seu posicionamento na sociedade. São relatadas reflexões acerca dos resultados alcançados quanto à aplicação das metodologias, motivação para a área de exatas e o impacto do projeto na escola e nas escolhas das alunas.

Palavras-chaves: Equidade de Gênero, Metodologias Ativas; STEM

1 Introdução

A posição de coadjuvante da mulher perante a sociedade tem origem no Brasil colonial. Segundo Ribeiro (2000), nessa época, por mais de 3 séculos, a educação escolarizada feminina não era vista como essencial, às mulheres cabiam, geralmente, os cuidados com a casa, o marido e os filhos.

Dessa forma, características ditas como femininas, tais como a fragilidade e delicadeza, colocaram a mulher em uma posição inferiorizada na hierarquia social, desfavorecendo a sua atuação nas áreas tecnológicas. Segundo Bonneti e Lima (2011), mesmo com o avanço científico, ainda se insiste em conferir valor diferenciado às características supostamente masculinas e femininas, nivelando essas diferenças sempre com as mulheres sendo prejudicadas.

Esses estereótipos quanto à atuação das mulheres na sociedade e as diferenças de educação de meninos e meninas também são verificados no mundo e refletem nas carreiras associadas às Ciências, Tecnologias, Engenharias e Matemática (Kessels, 2014; Smyth FL & Nosek, 2015; Miller, Eagly & Linn, 2014).

Nessas áreas, o percentual de mulheres é bem inferior ao de homens e para minimizar as diferenças deve-se combater os estereótipos e preconceitos que permeiam a sociedade.

É nesse contexto que, na Universidade de Brasília, surge o projeto Meninas Velozes. Apoiado por um grupo de professoras e estudantes das engenharias e das áreas de ciências sociais, educação e psicologia, o projeto visa a mobilização de alunas de uma escola pública de Ensino Médio do Distrito Federal a conhecerem e se interessarem pelos cursos universitários nas áreas exatas e tecnológicas, em especial as engenharias.

O artigo tem como objetivo apresentar ações desenvolvidas no escopo do projeto para despertar o interesse de jovens mulheres, estudantes do ensino médio, pela área de exatas e realizar reflexões acerca de intervenções socioeducativas executadas com esta finalidade.

As ações educacionais são baseadas em metodologias ativas e contextualizadas, organizadas em oficinas com foco nos conceitos e experiências em Ciências, Tecnologias, Engenharia e Matemática, fundamentais para as áreas das exatas, em visitas ao ambiente universitário e também com oficinas e rodas de conversa, em que são discutidos e confrontados estereótipos de gênero.

2 Em busca de uma aprendizagem mais eficiente

Segundo Diesel et al. (2017), conjectura-se que toda atividade proposta com a finalidade de ensinar deve ser pensada sob a perspectiva daqueles que a integram, ou seja, o momento do planejamento e organização das práticas educacionais devem ser articulados de forma que os estudantes participem mais ativamente desse processo, já que a aprendizagem destes, é a principal finalidade da ação educativa.

No método de ensino tradicional massivamente aplicado nas instituições, cabe ao estudante absorver uma grande quantidade de informações passivamente, sem que a este seja dada a oportunidade, muitas vezes, de se manifestar e posicionar criticamente. (Diesel et al., 2017). A metodologia ativa busca em primeiro lugar a prática, seguida de uma reflexão a respeito para, por fim, fundamentar os conceitos teóricos envolvidos. Segundo Abreu (2009), primeiramente, uma situação problema é proposta pelo professor para que os alunos possam, assim, questionar e pesquisar a fim de encontrarem uma solução, fazendo com que o aluno seja o centro do processo de aprendizagem.

Além disso, o uso de metodologias ativas permite que os estudantes possam discutir e trocar conhecimento a partir das situações expostas pelo docente. Ou seja, a interação entre os estudantes é favorecida, em contraponto a aulas expositivas, nas quais os alunos devem permanecer em carteiras individuais, "proibidos" de interagir com os colegas. (Diesel et al., 2017).

Cabe salientar que os prenúncios da metodologia ativa não é algo recente, já que segundo Abreu (2009), há indícios do que seria a essência dos métodos ativos na obra Emílio de Jean Jacques-Rousseau (1712-1778), onde o filósofo já nessa época valorizava a experiência, que deveria preceder os aspectos teóricos.

Dessa forma, em busca de novas alternativas que criem uma aprendizagem mais eficiente, nas quais o aluno possua uma postura mais ativa, surge o projeto Meninas Velozes para o desenvolvimento de oficinas temáticas voltadas para o ensino médio.

3 Políticas públicas para representatividade nas exatas

A baixa representatividade de mulheres nas áreas de exatas foi foco de algumas ações nos anos de 2012 a 2014 por meio de editais de fomento voltados para instituições públicas de ensino superior no sentido de criar projetos e programas que envolvessem escolas de ensino médio. Têm-se como exemplos o CNPq e o Fundo Elas, que através de editais e programas buscam auxiliar grupos menores a mudarem tal realidade.

Tais incentivos contribuíram para a criação do Projeto Meninas Velozes em 2013. O projeto foi se estruturando nos anos seguintes, mas ainda se fazem necessárias mais ações para alcançar maior consolidação.

Um levantamento de dados realizados na plataforma SIGRA da Universidade de Brasília, no segundo semestre de 2017, aponta a disparidade no que se refere à porcentagem de alunos com o de alunas nos cursos de engenharia. A Tabela 1 mostra tais percentuais, bem como uma comparação entre os cursos de engenharia.

Tabela 1 Relação de mulheres nos cursos de engenharia da Universidade de Brasília em 2017

Curso	Departamento	Total de alunos	Mulheres	Mulheres (%)
Eng. Florestal	EFL	458	248	54,1
Eng. Ambiental	ENC	378	194	51,3
Eng. Energia	FGA	243	113	46,5
Eng. Química	IQ	382	171	44,8
Eng. Produção	EPR	576	209	36,3
Eng. Civil	ENC	504	132	26,2
Eng. Aeroespacial	FGA	280	68	24,3
Eng. Eletrônica	FGA	397	89	22,4
Engenharias	FGA	877	173	19,7
Eng. Elétrica	ENE	517	93	18,0
Eng. Redes	ENE	344	53	15,4
Eng. Mecatrônica	ENE, ENM, CIC	413	60	14,5
Eng. Mecânica	ENM	504	73	14,5
Eng. Software	FGA	437	59	13,5
Eng. Computação	ENE, CIC	401	42	10,5
Eng. Automotiva	FGA	182	15	8,2

Nota-se uma discordância em relação ao número geral de alunas e também nos percentuais entre os cursos. Percebe-se que mesmo dentro das engenharias, ainda há aquelas consideradas mais masculinas ou mais femininas.

Assim, a fim de defrontar o sistema, há a necessidade de se buscar possibilidades não baseadas nas ditas regras societárias acerca da questão de gênero no que tange às escolhas profissionais. Desse modo, o projeto Meninas Velozes tem por finalidade suscitar o interesse das alunas do ensino médio da rede pública em áreas das ciências exatas e tecnológicas, visando uma maior adesão delas nesses cursos. Assim, contribui-se para diminuir a disparidade entre o número de meninas e meninos nessas áreas.

O projeto, por meio da integração entre as alunas do ensino superior e médio, estimula as que se encontram no ensino superior a refletirem, por um ângulo fora da realidade delas, sobre questões sociais. Além disso, elas são levadas a ponderar sobre as próprias dificuldades encontradas em seus cursos por serem garotas. Desse modo, há um anseio advindo de ambas as partes pela construção de um ambiente de ensino-aprendizagem motivador, resultando em discussões a respeito das questões de gênero nos cursos de exatas. Desde a sua criação, o projeto já atendeu cerca de 100 alunas do Ensino Médio.

3.1 A aplicação do método

A metodologia utilizada pelo projeto baseia-se nos princípios da pesquisa-ação, composto por duas etapas principais: a estruturação do ambiente de aprendizagem e a sua análise.

O projeto aborda a aprendizagem ativa, em que as alunas são estimuladas a adquirirem conhecimento de forma autossuficiente, ou seja, buscam uma autonomia intelectual. Junto a isso, há a aprendizagem significativa, que diz respeito a uma junção entre os conceitos prévios e as novas informações abordadas durante as oficinas. Desse modo, há uma maximização do aprendizado das alunas.

Nesse contexto, a aprendizagem colaborativa também se faz presente no âmbito de proporcionar um aprendizado natural, contrapondo-se ao ensino maquinizado comum da aprendizagem estruturada, no qual o aluno é mais levado a decorar do que realmente aprender e consolidar os conceitos trabalhados. Assim, são realizadas atividades em que as alunas são desafiadas, fazendo-as desenvolver um raciocínio a fim de que encontrem uma solução para os problemas propostos, de forma a atingir os objetivos finais. Há de se ressaltar que os resultados podem ser potencializados pelo trabalho de equipe entre as alunas, através da criação de um ambiente favorável à aprendizagem.

Desse modo, a estruturação do ambiente de aprendizagem, desenvolvida pelo projeto de maneira a se mostrar presente um ambiente favorável, é sistematizado através de dinâmicas de integração, oficinas práticas, palestras e visitas técnicas.

As dinâmicas de integração são realizadas duas vezes por ano, no início de cada semestre letivo. Tais dinâmicas buscam integrar as alunas do ensino médio com as alunas da graduação, de modo a gerar um intercâmbio de experiências e conhecimento. Essa atividade é importante pois promove uma maior aproximação entre as envolvidas e é uma oportunidade de se conhecer possíveis dúvidas, dificuldades e até mesmo o desempenho das alunas.

Nas oficinas práticas, inicialmente as alunas de graduação fazem junto às alunas do ensino médio uma aula-revisão sobre diversos conceitos da física e matemática. Posteriormente, são realizadas atividades e oficinas práticas baseadas nos conhecimentos adquiridos. O objetivo das atividades é estimular as alunas uma discussão sobre as situações propostas e a busca dos recursos didáticos úteis para elas, conduzindo-as apenas quando necessário. Algumas das atividades, são semelhantes a jogos, onde as alunas são separadas em grupos para que se crie uma atmosfera competitiva.

As palestras possuem como finalidade apresentar às alunas as áreas das ciências exatas e tecnológicas na visão de profissionais que atuam nessas áreas para mostrar suas rotinas e experiências. Elas relatam toda a adversidade e obstáculos que tiveram que enfrentar para conseguirem atingir seus objetivos e tornarem-se mulheres de sucesso em um meio que se faz necessário possuir persistência para não se abalar. Essas palestras são de suma importância, pois, por diversas vezes, há a falta de uma imagem que sirva de inspiração, como forma de combater toda uma cultura ultrapassada que clama por mudanças.

Através das visitas técnicas, as alunas aumentam seus conhecimentos sobre a tecnologia desde a sua história até sua presença na atualidade. São realizadas também visitas a exposições que mostram fatos e figuras femininas importantes da história no que diz respeito a luta pela igualdade de gêneros. A Figura 1 mostra uma esquematização da metodologia utilizada no projeto.

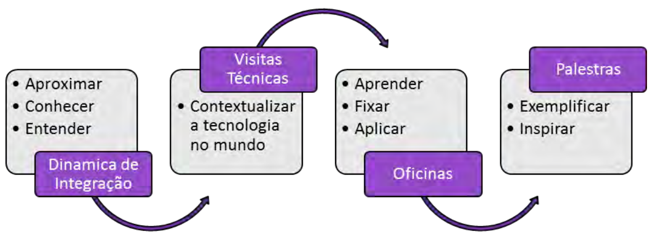

Figura 1. Ações integradas no projeto.

3.2 Análise do método

O desenvolvimento de cada atividade é baseado em determinar qual será o assunto tratado, como será a abordagem, em forma de oficina, palestra ou visita, e aplicar da maneira que promova uma aprendizagem significativa, instigando na busca por mais conhecimento.

Dentre as várias oficinas, duas são descritas neste trabalho visando mostrar a metodologia ativa aplicada às alunas no projeto: "Tempo e Movimento" e "Desenho e impressão 3D".

3.2.1 Tempo e movimento

Para a oficina Tempo e Movimento, o assunto tratado consiste em conceitos cinemáticos da física. Apesar de serem muito presentes no dia a dia, percebe-se uma dificuldade por parte das alunas de ensino médio de relacionar a teoria com a prática.

As alunas de graduação planejam a oficina onde deverá conter uma rápida introdução da teoria através de uma aula revisional, seguida pela sua aplicação prática.

Durante a introdução são explicados conceitos de "espaço", "tempo" e "velocidade", mostrando a formulação das equações presentes, a relação entre si e os exemplos no dia a dia.

Para a parte prática, pensa-se em uma maneira simples e lúdica de expor o conteúdo abordado. Para isso, utilizam-se carrinhos de controle remoto, cronômetro, trena e fitas sinalizadoras. A construção e o desenvolvimento da parte prática do experimento são feitos da seguinte maneira:

- Utilizando a fita métrica e as fitas sinalizadoras, são construídos, pelas monitoras, três trajetos no chão, uma circular, uma curvilínea e uma reta;
- Dividem-se as alunas do ensino médio em três grupos;
- Para cada grupo são entregues formulários onde devem ser registrados dados obtidos em cada trajeto. Esses dados são: distância percorrida, tempo e velocidade.
- Com uma trena, cada grupo deverá medir a distância e o deslocamento de cada trajeto, registrando no formulário;
- Cada grupo deverá fazer o carrinho de controle remoto percorrer o trajeto e registrar o tempo gasto no percurso, utilizado um cronômetro;
- Utilizando os dados do deslocamento e do tempo, cada grupo deverá calcular a velocidade obtida por cada carrinho;
- Analisa-se e compara-se cada valor obtido;

O experimento coloca as alunas em uma situação em que é necessária maior concentração tanto para diferenciar os conceitos quanto para registrar e calcular os valores. É exigido das alunas também a capacidade de diferenciar unidades de medidas e relacioná-los às unidades internacionais.

3.2.2 Desenho técnico e impressão 3D

A oficina de desenho em 3D aborda noções de desenho técnico e processos de fabricação na área de engenharia. Para isto, utiliza-se o "*solidworks*", um programa de construção de elementos em 2D e 3D, muito utilizado nas áreas de engenharia, arquitetura e design.

Nesta oficina são apresentadas noções de desenho técnico através do "*solidworks*" e os recursos básicos necessários para operar o programa. São disponibilizados às alunas um material contendo uma breve explicação sobre o programa e alguns de seus recursos básicos e um tutorial da peça a ser criada, que consiste em um carro inspirado no logo do projeto Meninas Velozes.

Após a confecção do carrinho, os desenhos criados pelas alunas são enviados para o laboratório de impressão 3D. Com o carro impresso são criados chaveiros. De uma forma geral, nota-se que as alunas conseguem concluir o objetivo com sucesso, algumas com mais e outras com menos facilidade. Ao longo da realização da oficina conta-se com o auxílio das monitoras do projeto que foram previamente treinadas.

4 Resultados

Ao longo do projeto foram sendo observados alguns pontos no que se refere ao comportamento e ao pensamento das alunas nos momentos iniciais e depois de um tempo de participação do projeto. Um dos pontos é sobre a mobilização das alunas de uma escola do ensino público sobre a questão da divisão sexual do trabalho. O outro ponto foi sobre a influência de um método educacional ativo na real aprendizagem e no despertar de interesses em determinados assuntos.

Através de pesquisas e relatos, foram observados que as alunas do Ensino Médio, ao ingressarem no projeto, ainda possuem uma concepção de que as mulheres possuem uma maior capacidade para a carreira de serviços, enquanto que os homens às engenharias e áreas tecnológicas, e que quando uma mulher se difere e segue pela área das exatas, esta se mostra com um potencial diferenciado e se torna uma exceção. Com isso, as atividades realizadas no projeto, conduzidas por alunas e professoras das engenharias tornaram-se exemplos contrários a essas concepções, gerando uma proximidade com uma realidade diferente da imaginada. A errônea ideia de uma divisão de trabalho entre homens e mulheres, convencionada pela sociedade é então posta em questão e discutida ao longo do projeto.

O outro ponto em questão mostrou a eficiência na utilização de uma metodologia ativa. Ao se propor um aprendizado mais ativo e colaborativo nas oficinas, as alunas foram tiradas de uma posição quase sempre passiva, que se resumia em um professor lhes apresentar o conteúdo do qual ele tinha domínio, para uma posição em que agora, elas poderiam buscar esse conhecimento e criar as suas próprias experiências. Cada conteúdo que antes era visto apenas de maneira teórica, passou a ser visto de maneira prática e concreta no campo da engenharia.

5 Conclusões

O projeto "Meninas Velozes" conta com a participação de alunas do ensino médio do colégio CEM 404 da cidade de Santa Maria, localizada no Distrito Federal, assim como de alunas e professoras das engenharias da Universidade de Brasília. Através das atividades realizadas, que consistem em dinâmicas de integração, oficinas práticas, palestras e visitas técnicas, percebe-se que é possível aumentar o interesse das alunas a optarem pelos cursos das áreas de engenharia e tecnologia, colaborando para diminuir a discrepância entre os profissionais de sexos diferentes que existe nesta área.

O método educacional utilizado no projeto, através de metodologias ativas, utiliza-se de atividades e jogos competitivos em grupos, que envolvem as alunas de modo lúdico e interativo ao complexo mundo da Física, Matemática e Química, tornando-o mais atraente. Além disso, cria-se, nas oficinas práticas um ambiente motivacional de ensino e aprendizagem, no qual se evidencia uma experiência de aproximação entre as universitárias dos cursos de Engenharia com as adolescentes de Ensino Médio, proporcionando que as graduandas possam contribuir socialmente para a criação de um espaço reflexivo sobre inclusão social e questões de gênero nas exatas.

Por ser um projeto relativamente novo e, devido à dificuldade de acompanhar as alunas após suas graduações no ensino médio, ainda é difícil mensurar a quantidade de meninas que optaram de fato pela área das exatas. Apesar disso, é evidente o comprometimento das meninas às atividades do projeto.

Por fim, já é uma grande conquista inseri-las no ambiente universitário e que, caso não venham a optar por uma carreira na área das exatas, que seja por falta de afinidade e não por causa de algum estereótipo de gênero.

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PAEE/ALE'2018 ABSTRACT SUBMISSIONS

Submissions of abstracts accepted for the PAEE/ALE'2018 poster sessions.

Teachers' Perspectives about Curriculum Development in Engineering Education: Implications for academic work

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Abstract

The educational changes under the Bologna Process have challenged, amongst other issues, the teaching practice in Higher Education (HE). The teacher is a key element to create meaningful learning experiences in order that students have the opportunity to develop a wide range of competences related to their professional practice. Nevertheless, the curriculum and the pedagogical practice are not always aligned with this purpose. This work focuses on the teachers' perspectives about curriculum development in Engineering Education. Four focus group were conducted with a total of 14 teachers from engineering, science and technology background. Implications for academic work will be discussed in the final paper.

Keywords: Engineering Education; Curriculum Development; Academic Work

Pedagogical Competences in the Context of Active Learning in the Perception of Engineering Teachers in Brazil

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Abstract

The implementation of new educational models, in which students are in the center of the learning process and are stimulated to find solutions to real problems, still faces some barriers when faced with the conventional teaching-learning processes. This issue is especially important because the teacher is a fundamental agent in the creation of learning contexts that allows students to develop a set of competencies related to their professional practice. In this context of pedagogical and curricular innovation, with student-centered active learning strategies, the development of pedagogical skills of teachers has been increasingly discussed. Considering the problematic of teacher professional development in higher education, we present the perceptions of 205 professors of engineering courses in Brazil. These perceptions are focused on the main pedagogical skills, and how to develop them in the context of active learning. The results show that, for the interviewed teachers, the most important competences are: teamwork (cooperative work with other teachers); relation with students (empathy); give feedback throughout the learning process; use of new technologies; selection of methodologies in the teaching-learning process and creativity. Such competences are important for the innovation of teaching practice in the context of active learning, which improves the professional training of engineers in the current global scenario.

Keywords: Higher Education; Active Learning; Engineering Education; Project-Based Learning; Pedagogical Competences.

Competências Pedagógicas no Contexto de Aprendizagem Ativa na Percepção de Professores de Engenharia no Brasil

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Resumo

A implantação de novos modelos educacionais, nos quais os estudantes sejam mais participativos e estimulados a encontrar soluções para problemas reais, ainda encontra algumas barreiras quando se defronta com o modelo convencional de ensino-aprendizagem. Essa questão ganha especial importância porque o docente é um agente fundamental na criação de contextos de aprendizagem que permita aos estudantes desenvolverem um conjunto de competências relacionadas com a sua prática profissional. Neste contexto de inovação pedagógica e curricular, com estratégias de aprendizagem ativa centradas no estudante, o desenvolvimento de competências pedagógicas dos docentes vem sendo cada vez mais discutido. Considerando a problemática do desenvolvimento profissional docente no ensino superior, apresentam-se neste estudo as percepções de 205 professores de cursos de Engenharia no Brasil. Essas percepções estão centradas nas principais competências pedagógicas, e como desenvolvê-las no contexto da aprendizagem ativa. Os resultados apontam que, para os professores inquiridos, as competências mais importantes são: trabalho em equipe (trabalho cooperativo com outros professores); relacionar-se com os alunos (empatia); dar feedback

ao longo do processo de aprendizagem; utilização de novas tecnologias; seleção de metodologias no processo de ensino-aprendizagem e a criatividade. Tais competências são importantes para a inovação da prática docente no contexto da aprendizagem ativa, que melhoram a formação profissional dos engenheiros no atual cenário global.

Palavras-chave: Ensino Superior; Educação em Engenharia; Aprendizagem Ativa; Aprendizagem baseada em Projetos; Competências Pedagógicas.

PAEE/ALE’2018 POSTER SUBMISSIONS

Submissions accepted for PAEE/ALE’2018 poster session.

The presence of black women in Brazilian Engineering

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Abstract

The engineering areas are mainly male and white environments. Women began to arrive much later, black men were gradually entering, but no one thinks there are black female engineers. The challenges are in the distrust of the quality of the student that unites several factors of bulling, like being a woman, being black and being of the majority, of a disadvantaged economic class. Challenges range from systematic discouragements, from a young age to an academic life. The study of case is the Polytechnical School of the University of São Paulo, in which 11 black brazilian women could overcame this cycles of exclusion and they achieved an engineer diploma inside more than 120 years of this institution.

Keywords: Black woman, Engineering, Diversity

A presença de mulheres negras na Engenharia Brasileira

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Abstract

As áreas de engenharia são principalmente ambientes masculinos e brancos. As mulheres começaram a chegar muito mais tarde, os homens negros estão gradualmente entrando. Mulheres negras, porém, ainda são em número diminuto no setor de engenharia, apesar de elas comporem 25% da população brasileira. Os desafios perpassam os desencorajamentos sistemáticos, desde tenra idade até a vida acadêmica, o que resulta em baixa diversidade nos cursos de engenharia. O estudo do caso é a Escola Politécnica da Universidade de São Paulo, na qual 11 mulheres brasileiras negras puderam superar esses ciclos de exclusão e obtiveram um diploma de engenharia dentro de mais de 120 anos desta instituição.

Keywords: Mulheres negras; Engenharia; Diversidade

1 Introdução

O Brasil tem desigualdades que se refletem em todos os setores da sociedade e na engenharia não é diferente. Para entender as desigualdades é preciso monitorá-las.

As áreas de engenharia são principalmente ambientes masculinos e brancos. As mulheres começaram a chegar muito mais tarde, os homens negros estavam gradualmente entrando, mas a presença feminina negra ainda é escassa nos dias de hoje.

Mulheres negras representam 25% da população brasileira, isto é mais de 50 milhões de pessoas. São um quarto do total de cidadãos do nosso país e vivem, em sua maioria, em condições de pobreza e na luta permanente contra a discriminação (RAMOS, 2013).

As brasileiras pioneiras na profissão começaram a conquistar seu espaço no início do século 20. Em 1917, Edwiges Maria Becker Hom'meil entra para a história como a primeira engenheira do Brasil, formada pela Escola Polythecnica do antigo Distrito Federal, hoje a Escola Politécnica da UFRJ. (Construct, 2016)

A pioneira a se graduar em engenharia na Escola Politécnica da Universidade de São Paulo, em 1928, foi Anna Fridda Hoffman, que mais tarde integrou-se ao Instituto de Pesquisas Tecnológicas como funcionária. A segunda engenheira só se graduaria em 1945: Josephina Pedroso Rosenburg exerceu a docência em Engenharia Química, por pouco tempo porém, do final dos anos 60 ao início dos 70 do século XX (Idem, p. 25-26). No entanto, nessa instituição, Alcina Maria Moura aparece como ouvinte, em 1904, e, na mesma condição, no Curso de Engenharia Civil, um ano depois. Segundo os parcos registros, ela optou pelo curso de engenheiros arquitetos logo depois (Idem). Alcina tinha apenas 15 anos (CABRAL, 2010).

Em 1945 Enedina Alves Marques se gradua em Engenharia Civil na hoje Universidade Federal do Paraná, tornando-se a primeira mulher engenheira e negra do Sul do Brasil (FERNANDES, 11 abr. 2014).

2 Os desafios

Apesar da participação masculina ainda ser muito superior à feminina no setor de engenharia, esta diferença está cada vez menor. Segundo dados do Sindicato dos Engenheiros do Estado de São Paulo, as mulheres continuam minoria na engenharia, mas em 2013 chegaram a 19% dos empregados formais. São 17.875 mulheres no total de 92.478 pessoas. Em 2003, eram 7.829 mulheres e representavam 15%. Outro dado significante é a redução da disparidade por gênero. Em 2003, as engenheiras tinham salários que representavam em média 75% dos pagos aos seus colegas do sexo masculino. Em 2013, já obtinham remuneração equivalente a 81% (ABES, 2015).

Hoje uma análise rápida das fotos de formatura na Escola Politécnica da Universidade de São Paulo, como a da Figura 20, não revelam a presença de negros e mostra o tamanho dos desafios, apesar da presença feminina já ser marcante.

Figura 20. Foto típica com formandos da EPUSP em frente à Catedral da Sé em São Paulo em 2016 (Coletivo de estudantes negros PoliNegra, 2017)

As ações afirmativas com reserva de vagas para afrodescendentes têm o objetivo de fazer diminuir a discrepância na presença de negros em áreas acadêmicas e lança-los ao mercado de trabalho mais capacitados e prontos para galgar melhores posições. Porém é um grande desafio a conclusão do curso de engenharia, porque os mecanismos das universidades devem ter bom funcionamento para garantir a permanência de negros provenientes dos setores menos economicamente desfavorecidos da sociedade brasileira. Os cursos de engenharia no Brasil são somente diurnos, com raríssimas exceções em universidades privadas paulistas. Os cursos de engenharia também são integrais e duração de cinco anos. Um somatório de barreiras que podem ser vencidas com apoio institucional.

Apesar da excelência acadêmica de mulheres negras, muitos são os fatores que podem levar ao afastamento desta parcela da sociedade das áreas da engenharia. Há desencorajmentos sistemáticos que impelem mulheres negras a não escolher a área, mas para as que escolhem, também há vários desafios relacionados à classe social, ao gênero e à raça.

Os desafios estão na desconfiança da qualidade do aluno que une vários fatores de bulling, como ser uma mulher, ser negra e ser da maioria, de uma classe econômica desfavorecida. Os bullyings são praticados por esta soma de vulnerabilidades e confere instabilidade aos desempenhos dos alunos. Apesar de várias décadas de pesquisa sobre bullying no local de trabalho, não existe uma definição universal do fenômeno. No nível mais básico, aqueles que são intimidados no local educacional experimentam algum tipo de comportamento negativo verbal ou não verbal, que pode ser realizado pelo agressor de maneiras abertas ou encobertas (Saunders et al., 2007). Além disso, o bullying resulta em danos fisiológicos ou psicológicos; aqueles que são intimidados têm menos poder do que seus perpetradores (Saunders et al., 2007).

Rayner e Hoel (1997) argumentam que existem vários tipos diferentes de bullying no local de trabalho, incluindo ameaça ao status profissional, ameaça à posição pessoal, isolamento, excesso de trabalho e desestabilização no local de trabalho. Além dessas definições, Escartín et al. (2011) argumentam que o bullying também pode incluir abuso emocional (humilhação ou outros insultos), descrédito profissional e menosprezar o trabalho e habilidades do indivíduo e a desvalorização do papel profissional (atribuindo tarefas de trabalhadores inúteis, sem sentido ou não combinar o nível de habilidade do empregado). Fox e Stallworth diferenciam entre bullying geral e "bullying racial / étnico", definidos como ações que direcionam especificamente a raça ou grupo étnico de uma pessoa ou racismo (2005: 438) Attell et al (2017). Porém os efeitos do bullying, em sua maioria são diminuir, menosprezar, já os efeitos do racismo e racismo institucional são mais fortes e perversos, visto que visa a eliminação do indivíduo daquele ambiente.

Para o certame vestibular que permite o ingresso nos cursos de engenharia, no ano de 2018, a Universidade de São Paulo decidiu aderir às ações afirmativas que já foram implementadas em outras universidades brasileiras há pelo menos dez anos.

Serão 126 vagas reservadas para negros e negras de escola pública na Escola Politécnica da Universidade de São Paulo no exame vestibular de 2018 (Jornal da USP, 2018) Porém até estes egressarem como engenheiras e engenheiros formados, serão necessários, no mínimo, mais cinco anos para o cenário de quase 30 mil formados pela EPUSP mude muito gradativamente.

3 Estudo de caso

O estudo do caso é a Escola Politécnica da Universidade de São Paulo, na qual 11 mulheres brasileiras negras puderam superar esses ciclos de exclusão e obtiveram um diploma de engenharia dentro de mais de 120 anos desta instituição.

Foram feitas entrevistas que evidenciaram a presença de 11 mulheres negras formadas em engenharia na Escola Politécnica da Universidade de São Paulo desde 1893. A primeira mulher negra formada na Escola Politécnica que se tem registro foi Thays de Souza Luis, formada em Engenharia de Minas em 2003. Thays também concluiu o mestrado na mesma área na EPUSP.

Figura 21. Cerimônia de colação de grau em engenharia da sexta mulher negra na Escola Politécnica da Universidade de São Paulo em agosto de 2015 (EPUSP, 2015)

Foi realizada também, pela primeira vez, uma reunião, em 2017, onde as mulheres negras politécnicas relataram as suas trajetórias. A reunião contou com oito engenheiras negras formadas e duas estudantes de engenharia da Escola Politécnica da Universidade de São Paulo, sendo que havia naquele momento mais três formadas e mais duas estudantes da EPUSP, assim totalizando 11 formadas e 4 estudantes mulheres negras que irão colar grau nos próximos anos. Não há relatos de mais do que 15 mulheres negras, entre atuais estudantes e já formadas, dentre o universo de quase 30 mil formados em mais de 120 anos na EPUSP.

Figura 22. A reunião oito engenheiras negras formadas e duas estudantes de engenharia da Escola Politécnica da Universidade de São Paulo (SVAAB, Coletivo de estudantes negros PoliNegra, 2017)

4 Conclusões

A diversidade na Engenharia enfrenta vários desafios, mas é necessário investimento em atratividade e retenção da diversidade, para que haja ganhos de qualidade na instituição e para que haja real crescimento do país, quando todos os indivíduos tenham oportunidades mais igualitárias de desenvolverem-se. As políticas públicas de reserva de vagas são o único caminho para aumentar a presença negra nos cursos de engenharia e ações para o combate ao racismo e ao racismo institucional, bem como políticas de permanência para pessoas em vulnerabilidade econômica são primordiais para assegurar a permanência de negras e negros em cursos superiores como engenharias. Não obstante, as empresas devem empenhar esforços de entendimento no momento da contratação de negras e negros, como por exemplo, não discriminação pela idade, pelo gênero, pela raça, pelos conhecimentos de idiomas estrangeiros.

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PAEE/ALE'2018 FULL PAPERS SUBMISSIONS (PORTUGUESE)

Submission 175 accepted for the PAEE/ALE'2018 papers sessions in Portuguese.

Please note that paper 175 "Mariane Felizardo da Silva Ferreira, Lucio Garcia Veraldo Junior and Benedito Manoel de Almeida, Análise das disciplinas básicas do curso de engenharia na formação das competências lógicas" was added at the end of the Proceedings.

Analysis of the basic disciplines of the Industrial Engineering course in the formation of logical competences

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Abstract

Upon entering an Engineering course, the student is faced with several disciplines related to Mathematics, Physics, Chemistry and Materials that make up the basic nucleus of any specialty, commonly developed in the first four semesters. The real objectives of these disciplines are related to the development of logical reasoning, systemic thinking and, mainly, problem solving ability. This differs the engineer from other professions. This article presents the analysis of teachers of the course of Production Engineering for the logical skills defined for the graduation of the course through the contribution of development while attending the basic core subjects. This process is an integral part of a scientific research in which it is expected to analyze the competencies defined by the activities assigned to the engineer by CONFEA and the CDIO INITIATIVE analyzing the disciplines for the new matrices of the Engineering courses that will be valid for incoming students from 2018.

Keywords: Logic Skills; Engineering; Basic Core; Disciplines.

Análise das disciplinas básicas do curso de Engenharia de Produção na formação das competências lógicas

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Resumo

Ao ingressar num curso de Engenharia, o aluno se depara com diversas disciplinas relacionadas a Matemática, Física, Química e Materiais que compõem o núcleo básico de qualquer especialidade, comumente desenvolvido nos quatro primeiros semestres. Os reais objetivos destas disciplinas estão relacionados ao desenvolvimento do raciocínio lógico, do pensamento sistêmico e, principalmente, na capacidade de resolução de problemas. Isso difere o engenheiro das demais profissões. Este artigo apresenta a análise de professores do curso de Engenharia de Produção para as competências lógicas definidas para o egresso do curso mediante a contribuição de desenvolvimento ao cursar as disciplinas do núcleo básico. Este processo é parte integrante de uma pesquisa cientifica na qual se espera analisar as competências definidas pelas atividades atribuídas para o engenheiro pelo CONFEA e pela INICIATIVA CDIO analisando as disciplinas para as novas matrizes dos cursos de Engenharia que valerão para os alunos ingressantes a partir de 2018.

Palavras-chaves: Competências Lógicas, Engenharia, Núcleo Básico, Disciplinas.

1 Introdução

A formação das competências lógicas caracteriza o egresso dos cursos de engenharia diante de outras profissões. O pensamento sistêmico, a formulação e a resolução de problemas são algumas destas competências que devem ser desenvolvidas durante o curso da graduação.

Segundo o CONFEA (Conselho Federal de Engenharia, Arquitetura e Agronomia), por meio da resolução n° 218 de 1973, a atividade 08 desenvolvida no exercício da profissão, é amplamente caracterizada durante o curso de graduação em qualquer especialidade da Engenharia, na qual atribui o ensino, pesquisa, análise, experimentação, ensaio, divulgação técnica e extensão.

De acordo com o CNE/CNS n° 11 (2002), as Diretrizes Curriculares Nacionais (DCN's) estabelecem o desenvolvimento do aluno nos cursos de Engenharia dentre todas as competências necessárias, as seguintes características lógicas descritas no seu artigo 4o, que seguem:

- I – Aplicar conhecimentos matemáticos, científicos, tecnológicos e instrumentais à engenharia;
- II – Projetar e conduzir experimentos e interpretar resultados;
- V – Identificar, formular e resolver problemas de engenharia;
- VI – Desenvolver e/ou utilizar novas ferramentas e técnicas;
- VIII – Comunicar-se eficientemente nas formas escrita, oral e gráfica;

Já o artigo 6° destas DCN's, definem que "todo o curso de Engenharia, independentemente de sua modalidade, deve possuir em seu currículo um núcleo de conteúdos básicos, um núcleo de conteúdos profissionalizantes e um núcleo de conteúdo específicos que caracterizem a modalidade". Com cerca de 30% da carga horaria mínima dos cursos, o núcleo básico deve conter os seguintes tópicos:

- I – Metodologia Científica e Tecnológica;
- II – Comunicação e Expressão;
- III – Informática;
- IV – Expressão Gráfica;
- V – Matemática;
- VI – Física;

- VII – Fenômenos de Transporte;
- VIII – Mecânica dos Sólidos;
- IX – Eletricidade Aplicada;
- X – Química;
- XI – Ciência e Tecnologia dos Materiais;
- XII – Administração;
- XIII – Economia;
- XIV – Ciências do Ambiente;
- XV – Humanidades, Ciências Sociais e Cidadania.

Importante destacar que, segundo as DCN's, os conteúdos de Física, Química e Informática, deverão ter obrigatoriamente atividades de laboratório. Nos demais conteúdos básicos, deverão ser previstas atividades práticas e de laboratórios, com enfoques e intensidade compatíveis com a modalidade pleiteada.

Segundo Santos (2003), O enfrentamento de situações complexas, a identificação e a resolução de problemas em Engenharia podem ser resolvidos por meio da exploração da interdisciplinaridade dos cursos. Os conhecimentos específicos e as respectivas disciplinas devem ser tratados de forma dinâmica, ao contrário do que acontece atualmente. As disciplinas em que a transmissão desse conhecimento ocorre devem estar integradas com disciplinas em que esse conhecimento possa ser aplicado. Além disso, impõe-se o oferecimento de disciplinas em metodologia de pesquisa, gerenciamento de projetos e identificação e de resolução de problemas em Engenharia que orientem os alunos no enfrentamento de situações complexas. Novamente, elas devem estar integradas às demais disciplinas do curso de graduação. Além disso, Veraldo Jr e Lourenço Jr (2014) já propõe a continuidade do estudo da relação das com as competências do egresso em Engenharia de Produção.

Diante do contexto apresentado, o objetivo deste artigo é analisar as competências lógicas definidas para o Engenheiro de Produção segundo a ABEPRO (Associação Brasileira de Engenharia de Produção) diante das disciplinas do núcleo básico do curso do Centro Universitário Salesiano de São Paulo (UNISAL). As competências definidas são: "Análise Quantitativa", "Análise Qualitativa", "Comunicação" e "Aprender Sempre".

Esta análise é parte integrante do projeto de pesquisa em curso na qual tem como principal resultado a definição de atividades ativas e métodos de avaliação para o desenvolvimento das competências básicas conforme apresentado na Figura 1:

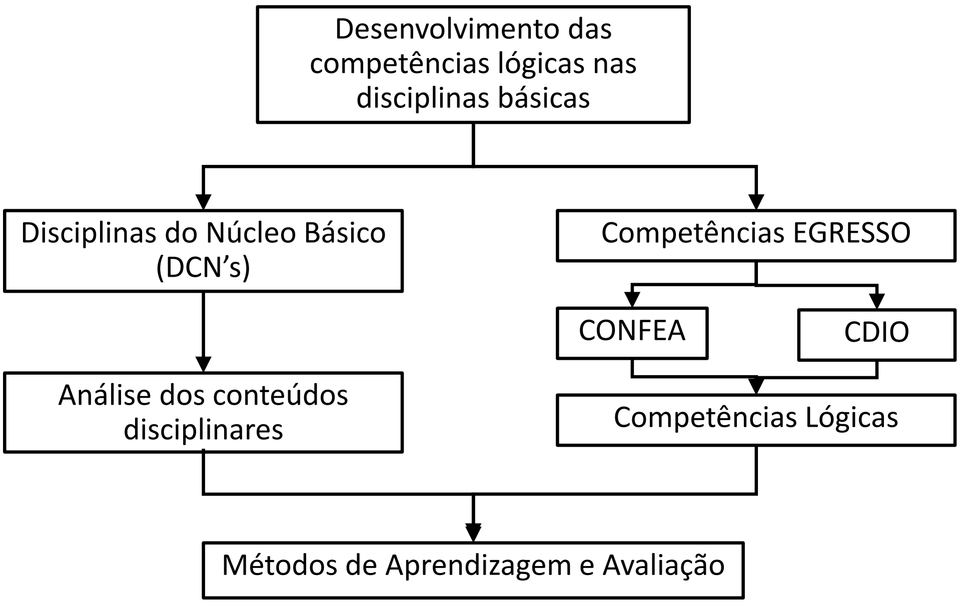

Figura 49. Fluxo de pesquisa geral.

Será apresentada uma revisão sistemática da literatura dos temas, estabelecendo por meio de relação das entidades estudadas as competências lógicas definidas para o egresso em engenharia, identificando o conteúdo das disciplinas que desenvolvem as mesmas. A justificativa do tema se deve a pesquisa cientifica em andamento caracterizando o desenvolvimento de competências desde o início dos cursos de Engenharia. Assim, resultados parciais são apresentados.

2 Bibliografia Fundamental

Bostrom, Gupta e Hill (2008) descrevem que um conjunto estruturado de atividades pedagógicas serve de guia, fonte de feedback e promove a aprendizagem colaborativa. Segundo estes autores, uma revisão da literatura educacional indica que as estratégias de aprendizagem das organizações acadêmicas estão se deslocando para uma aprendizagem mais ativa e voltada ao aluno como protagonista é denominada aprendizagem cooperativa ou colaborativa.

2.1 Matriz Curricular de Engenharia

Os cursos de graduação em engenharia no Brasil têm procurado, através de mudanças periódicas, equacionar esses problemas e modernizar seus currículos. Entretanto, por uma série de razões, pouco evoluíram em relação ao ensino praticado nos anos 70. Isso representa para os educadores da área, alguns problemas fundamentais que têm permanecido sem solução, no que tange ao planejamento, elaboração e implementação dos cursos de graduação em engenharia com vista a adequar tais cursos ao cenário vigente, assim como sua interação com o exercício desse profissional. É preciso enfrentar este desafio de forma rápida e eficaz (BORGES; ALMEIDA, 2013).

As diversas especialidades dos cursos de Engenharia determinam uma significativa gama de disciplinas para atenderem a todos os interesses da sociedade em geral, caracterizando o desenvolvimento de competências pessoais, interpessoais e profissionais. Porém, é válido destacar a formação básica dos conhecimentos matemáticos e físicos remetem a todos os cursos afinal, servirão de suporte para as disciplinas específicas.

Bazzo e Pereira (2003) afirma que a forma como os cursos superiores têm sido estruturados dificulta o imprescindível encadeamento lógico entre as diversas atividades que os compõem, fazendo com que os alunos se sintam desmotivados, pois não entendem onde irão usar o que estão aprendendo.

2.2 Ensino de Engenharia

Para Morán (2015) é muito importante que as metodologias de ensino aprendizagem sejam acompanhadas por objetivos pretendidos pela instituição e aprendizagem aos alunos. Se a instituição quer que seus alunos sejam proativos, é necessário adotar metodologias em que os mesmos se envolvam em atividades, com cada vez mais interesse, em que tenham que tomar decisões e avaliar os resultados, com apoio de materiais relevantes para autoconhecimento.

Para Crawley *et al* (2007), os objetivos para os cursos de graduação em Engenharia, tem as seguintes propriedades:

- Ter a prática moderna da engenharia de modo que as intenções do objetivo fluam naturalmente nos papéis reais da profissão dos engenheiros;
- Ser abrangente o suficiente de modo desenvolvendo ao máximo as práticas na educação em engenharia;
- Ser completo e consistente, na medida em que todos os conhecimentos, habilidades e atitudes esperados para a graduação do engenheiro estejam incluídos;
- Ser apresentado de forma suficientemente detalhada em que os tópicos específicos possam ensinados e aprendidos, estabelecendo as bases para o planejamento do currículo e avaliação baseada em resultados;
- Ser ligado a um processo de pesquisa que estabelecerá níveis de proficiência amplamente acordados que seria esperado de um engenheiro graduado;
- Expressar por meio de uma linguagem específica e formal, os objetivos de aprendizagem, o que deverá conduzir a uma interpretação coerente e avaliável do nível desejado de proficiência.

2.3 Competências Lógicas

Para Leme (2012), a competência "CHA" é composta pelos seguintes elementos: Conhecimento, Habilidade e Atitude, sendo que: "O Conhecimento é o Saber, é o que aprendemos nas escolas, universidades, nos livros, no trabalho, na escola da vida". Sabemos de muitas coisas, mas não utilizamos tudo o que sabemos. A Habilidade é o Saber fazer, é tudo o que utilizamos dos nossos conhecimentos do dia a dia. Já a Atitude é o que nos leva a exercitar nossa habilidade de um determinado conhecimento, pois ela é o querer fazer.

Segundo Bloom et al (1983), as habilidades estão associadas na capacidade de estudantes resgatarem e utilizarem seus conhecimentos prévios sobre o tema da disciplina, seus conhecimentos de mundo e suas experiências de vida, bem como as técnicas utilizadas para solucionar um problema atual, ou seja, está inter-relacionado, o que faz com que a competência seja um conjunto de aptidões que une os conhecimentos, as habilidades e as atitudes sobre determinada área.

Baseados na associação de habilidades gerais e específicas, o aluno de Engenharia desenvolverá ao longo de sua formação uma relação entre o raciocínio de engenharia e a solução de problemas de acordo com Crawley *et al* (2007), conforme apresentado na Figura 2:

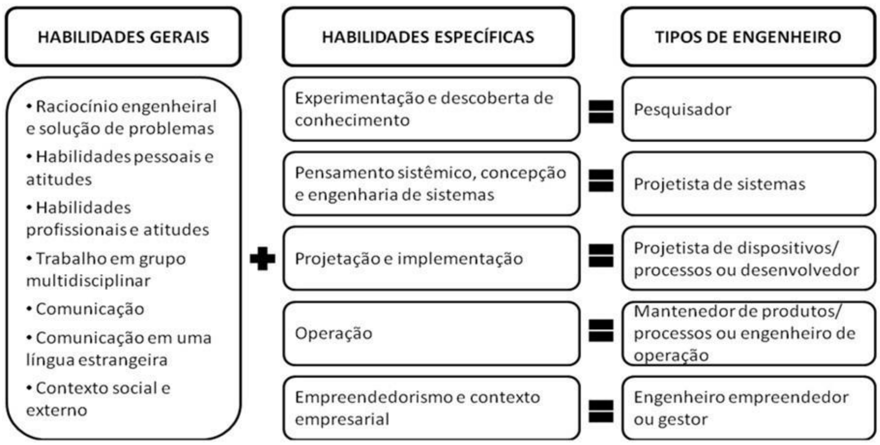

Figura 2 – Percursos da carreira profissional para Engenheiros (Crawley *et al,* 2007)

3 Objeto de Estudo e Método de Pesquisa

De modo a validar o método a ser aplicado no projeto de pesquisa científica apresentado na Figura 1 foi realizado junto aos professores do curso de Engenharia de Produção uma pesquisa na qual deveria ser definido o grau de contribuição de cada disciplina avaliada no desenvolvimento das competências lógicas. Este processo de avaliação é descrito na Figura 3.

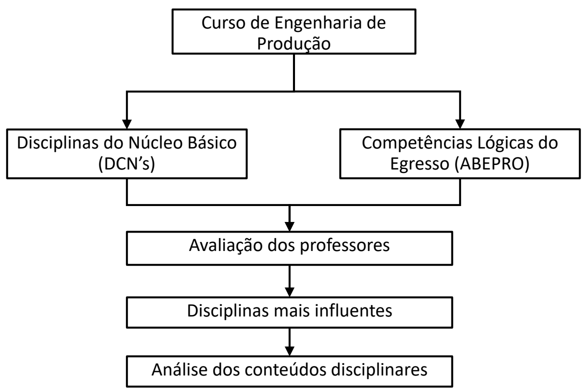

Figura 3 – Processo de avaliação das competências lógicas – projeto piloto na Engenharia de Produção

O método de pesquisa do presente artigo refere-se a um estudo de caso no curso de Engenharia de Produção do UNISAL em sua Unidade de Lorena tendo como resultado definir as disciplinas mais influentes para o desenvolvimento de competências lógicos definidas para este egresso. Segundo Westbrook (1995), nos estudos de caso, o pesquisador documenta uma situação existente na organização. A principal tendência é que estes tentam esclarecer o motivo pelo qual uma decisão ou um conjunto de decisões foram tomados, como foram incorporadas e com quais resultados alcançados (YIN, 2001).

Para avaliar as disciplinas os professores deveriam atribuir uma escala de influência de cada disciplina do núcleo básico. Importante salientar que todos os professores avaliaram todas as disciplinas mediante ao conhecimento prévio da ementa. Esta escala de avaliação é apresentada na Tabela 1.

Tabela 1. Grau de influência na contribuição das disciplinas.

Grau de Influência	Contribuição
1	Muito Pouco
2	Pouco
3	Moderadamente
4	Fortemente
5	Muito fortemente

4 Análises dos Resultados

Os resultados da avaliação realizada pelos professores são apresentados na Tabela 2 avaliando as disciplinas do curso de Engenharia de Produção definidas pelas DCNs como básicas para os cursos de Engenharia.

Tabela 2. Contribuição das Disciplinas no desenvolvimento das competências.

Disciplinas	Análise Quantitativa	Análise Qualitativa	Comunicação	Aprender Sempre
Administração	3	4	5	4
Ciência e Tecnologia dos Materiais	4	5	4	5
Ciências do Ambiente	3	5	5	4
Comunicação e Expressão	NA	NA	NA	NA
Economia	5	4	4	3
Eletricidade Aplicada	4	4	3	4
Expressão Gráfica	4	2	4	4
Fenômenos de Transporte	4	4	4	4
Física	5	4	4	5
Humanidades, Ciências Sociais e Cidadania	NA	NA	NA	NA
Informática	3	4	4	4
Matemática	5	4	4	4
Mecânica dos Sólidos	NA	NA	NA	NA
Metodologia Científica e Tecnológica	4	5	3	5
Química	4	4	2	4

NA – não aplicável

As disciplinas “Física” e “Ciência e Tecnologia dos Materiais” tiveram maior resultado na influência do desenvolvimento das competências lógicas estudadas.

5 Considerações finais

Os conhecimentos básicos buscam desenvolver o raciocínio lógico, constituir a base para a formação tecnológica e possibilitar a formação de habilidades e posturas reconhecidamente necessárias ao Engenheiro. Para que estas competências e habilidades sejam atingidas cabe ao docente apresentar propostas alternativas que possam ser desenvolvidas extraclasse durante o semestre letivo.

Como indicação de trabalhos futuros pode-se avaliar os estudantes diante da expectativa e percepção quanto ao real desenvolvimento em determinada disciplina. Além disso, estabelecer propostas de atividades ativas no processo de aprendizagem das disciplinas que estabelecem as competências lógicas dos cursos de Engenharia.

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